CACAO

ITS CULTIVATION AND CURING

J. HINCHLEY HART

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CACAO

Photograph by Jacobson, Trinidad

EAST INDIAN GIRLS ON A CACAO ESTATE, TRINIDAD

CACAO

A MANUAL ON THE
CULTIVATION AND CURING OF CACAO

BY

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PREFACE

IT is with feelings of deepest sorrow that the preface to this work is written, for the author, my dear father, has passed away since "Cacao" was compiled. During the last few months of his life, while suffering from a painful malady, it was a labour of love for him to revise the proofs. His experience of cacao cultivation was wide, and his knowledge of the subject made him an authority whose advice was sought from all parts of the world. The publication of this book will form a lasting tribute to the memory of one whose whole interest was in his work, and it will, I hope, be of great value and help to many, especially in this beautiful island, where my father laboured so long and faithfully for the good of the public. On behalf of his family, I wish to thank those who have so kindly helped in the publication of the work, particularly Mr. Algernon E. Aspinall, the Secretary of the West India Committee, and Mr. A. E. Collens, of the Trinidad Government Laboratory.

MINERVA HART

COBLENTZ AVENUE
PORT OF SPAIN, TRINIDAD
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CHAPTER I

BOTANY AND NOMENCLATURE

THE cacao-tree is a native of tropical regions extending from Mexico through Central and South America and the West Indies to Brazil. The following species are on record :

(1) Theobroma cacao.	(6) Theobroma guianensis.
(2) ,, pentagona.	(7) ,, ovalifolia.
(3) ,, bicolor.	(8) ,, speciosa.
(4) ,, angustifolia.	(9) ,, microcarpa.
(5) ,, sylvestris.	

Only the first two species appear to be of commercial importance. The Mexicans gave to Theobroma cacao the name of *Cacaoquahuitl,* which has in great measure been retained in the word chocolate. The word " cocoa " is of commercial derivation.

Trees of Theobroma cacao grow, in some places, to 30 ft. or even 40 ft. in height. The average may be taken at 15 ft. to 25 ft. in West Indian cultivation, but size is chiefly dependent on the fertility of the soil.

The genus Theobroma is included under the order *Sterculiaceæ,* by Messrs. Bentham and Hooker in their " Genera Plantarum." The generic and specific characters are as follows, and are to be found in Grisebach's " Flora of the West Indies," and other works :

ORDER STERCULIACEÆ—TRIBE BUETTNERIEÆ

Generic Description of Theobroma	Calyx 5 partite, coloured. Petals 5 : limb cucullate, with a terminal, spathulate appendage. Column 10-fid. ; fertile lobes bi-antheriferous ; anthers bilocular. Style 5-fid. Fruit baccate, 5-celled ; cells pulpy, polyspermous. Embryo exalbuminous ; cotyledons fleshy, corrugate. Trees ; leaves entire ; pedicels fascicled or solitary, lateral.

Specific Description of T. Cacao — T. Cacao, L.—Leaves oblong, acuminate glabrous, quite entire; flowers fascicled; pericarp ovid-oblong 10 cosiate. Calyx rose-coloured; segments lanceolate, acuminate, exceeding the yellowish corolla; pericarp yellow or reddish, leathery, 6 to 8 in. long. Habitat, Trinidad—De Schach. Naturalised in Jamaica. *Dist.* St. Lucia. *Anderson.* (Guiana and Brazil.)

The species known as Theobroma cacao, covers innumerable varieties or forms, differing in shape of pods, in size and vitality of trees, in bearing capacity, and in colour, shape and quality of the bean. The many names under which varieties of this tree (Theobroma cacao) are known, do not constitute species, but must be merely considered as varieties of one species. These varieties probably owe their origin to seed variation and cross-breeding, together with the local influence of soil and climate, but it would serve no useful purpose to record names by which they are known, as these differ in each district, in each plantation, and in each country where they are grown.

Sir Daniel Morris in "Cacao and How to Cure it" (1882) made two classes only of the varieties of Theobroma cacao, *Criollo* and *Forastero.* In the author's "Cacao" (1900) three classes were noted, *Criollo, Forastero* and *Calabacillo.* But in the light of experience gained in the cultivation of Venezuelan and Nicaraguan varieties, these are now added to the list, under the Class I., as follows:

THEOBROMA CACAO

CLASS I. CRIOLLO.

TRINIDAD CRIOLLO.

(1) Var. *a.* Amarillo = Yellow, thin-skinned, bottle-necked.
(2) „ *b.* Colorado = Red, thin-skinned, bottle-necked.

VENEZUELAN CRIOLLO.

(3) Var. *a.* Amarillo = Yellow, thick-skinned, high-shouldered, sometimes pointed.
(4) „ *b.* Colorado = Red, thick-skinned, high-shouldered, sometimes pointed.

NICARAGUAN CRIOLLO.

(5) Var. *a.* Amarillo = Yellow
(6) „ *b.* Colorado = Red
Thick-skinned, high-shouldered, and very large beans with light-coloured interior.

CLASS II. FORASTERO.

(7) Var. *a.* Cundeamor veraguso Amarillo = Yellow-warted.
(8) „ *b.* „ „ Colorado = Red-warted.

(9)	,,	c.	Ordinary, or typical Amarillo	=Yellow Forastero.
(10)	,,	d.	,, ,, Colorado	=Red Forastero.
(11)	,,	e.	Amelonado Amarillo	=Yellow, melon shaped.
(12)	,,	f.	Amelonado Colorado	=Red, melon shaped.

CLASS III. CALABACILLO.

(13)	Var.	a.	Amarillo = Yellow	Calabacillo, flat-beaned, smooth, thin- or thick-skinned, and small pods.
(14)	,,	b.	Colorado = Red	

THEOBROMA PENTAGONA

(15) Theobroma Pentagona = Alligator cacao. Has yellow, much-warted pods, with five distinctly raised ribs, and large beans, having white or light-coloured interior.

We have therefore a classification under *Theobroma cacao* carrying fourteen types under three classes, but it must be understood that these are separated by no definite margin, and that intermediate forms will be found on estates showing every conceivable form of variation. The tendency of variation appears to be in favour of the preservation of the lower qualities, and consequently to deterioration. This is unfortunately facilitated by the method of propagation from seed only, which has been used for long years past and is still the favourite method, and unless some radical change is made, many of the characteristics of the best cacaos must in time run the danger of extinction, a subject which is discussed more fully in subsequent pages under another head.

The word "Criollo" in our reading is to be interpreted as native, and the word "Forastero" as foreign, this kind, according to De Verteuil, having been imported from Venezuela to Trinidad long years ago, when its Criollo was struck with disease. Calabacillo is so named, owing to its being compared with some forms of the fruit of the "Calabash" (*Crescentia Cujete*).

The Trinidad Criollos and those coming from Venezuela and Nicaragua are placed together, as they afford produce of the highest quality, and all have beans with a white or light-coloured interior.

The Table is given as covering the chief types of cacao as

grown in the West Indies and tropical America. The Criollo varieties are chiefly distinguished by their white or light-coloured beans and by the high quality of their cured produce, and also by the less vigorous growth of the tree when compared with other varieties. The Venezuelan and Nicaraguan varieties are much alike, but in the Nicaraguan form the pod is frequently sharp-pointed at the base, well seen in the work of Dr. Preuss, Plate I., Fig. 2, also in Wright's work, 1907 edition, p. 28. These latter kinds produce beans of great size, but that of the Nicaraguan Criollo is the larger. The characters of the beans are also well shown by Preuss on page 166 of his work. The pods of Venezuelan and Nicaraguan Criollo are both high-shouldered, and stand in great contrast to the bottle-necked form of Trinidad Criollo, but the beans of all this class have the same white- or light-coloured interior. The identity of Trinidad Criollo is confirmed by its being found in virgin forest in that island. What is known locally as "Ocumare cacao" in Venezuela is a form of Venezuelan Criollo. In some of the Venezuelan and in some of the Trinidad Criollos there is a distinct approach in the form of the pod to that which is recognised as the type of Forastero cacao. Forastero cacao, as known in the West Indies, is a specially variable kind, that recognised as typical being a strong grower, bearing large rough ridged pods with beans varying in colour from individual trees and also from single pods. The colour of the interior of the beans ranges from light to dark purple, and they show a good average break; the better the bean, the more apparent is its blend with the Criollo, and it is of lower quality as it approaches the Calabacillo type.

Calabacillo cacao is inferior to the previously mentioned forms, but the type is a strong growing tree, which flourishes on lands where the better varieties refuse to thrive, and it can do with less shade; hence it is strongly recommended as a stock for grafting selected varieties. In appearance the pods are smooth and oval, the beans thin, solid, and darkly coloured. As they are heavier than those of high-

class cacao, and as the trees are generally good and regular bearers, this variety is selected by some planters as more suited to their purpose than trees bearing a better quality of produce, but it never obtains the same prices, although it may give remunerative returns.

In the foregoing description of really ideal type varieties, it should be fully understood that the cacao of the West Indies, in fact of most countries, consists of a heterogeneous mixture of cross-bred varieties of the one species (*Theobroma cacao*), though of late years it is thought possible that the common species may have become hybridised with *Theobroma pentagona*. Of this there is no positive proof, the strongest evidence being that the beans of the Criollo on the estates where *pentagona* is grown are much larger than on estates where it is absent, *T. pentagona* having the largest bean of any known species. In general, however, it is hard to say where one form begins and another ends. On most cacao estates, pods may be found illustrating by almost imperceptible differences the passage from Criollo on the one hand to Calabacillo on the other. In a paper read by the author before the first West Indian Agricultural Conference held at Barbados in 1899, it was stated :

> The only attempt hitherto made for the improvement of the quality of cacao is by selection of seed by external characters and the import of seed from other countries. The result is that to-day, although the remains of the original types are clearly apparent, it is also clear that, though bringing good prices, the cacao as now grown is as a whole nothing less and nothing more than an aggregation of cross-bred varieties. Some few might attempt to do so, but I think a wise planter would hesitate if he were asked to show where Criollo ended and Forastero began, or where Forastero ended and Calabacillo began. The fact is that the cacao of the West Indies is nothing more or less than a mixture of various strains, which again vary in and among themselves in no certain direction, and among which the characters of the ancient types appear more or less developed according to the character of their surroundings and the numerous influences which have been brought to bear upon them. The quality of the cacao produced from these strains (or types) is variable, some selling for good prices, while other brands are decidedly inferior. The character of the leaves, the form of growth, the colour and form of the fruit, the size, shape, and colour of the interior of the bean are all variable to a degree, and few trees can be found which are the exact counterpart one of the other either in their produce or the vegetative characters.
>
> The discovery (by the author in 1898) that cacao can easily be grafted by approach now puts into the hands of the planter means whereby he can secure a crop of one particular kind or kinds at will, and further it will enable him

to make samples of a character formerly impossible. It will also enable him to grow such types as the Criollo or any weak grower upon the vigorous growing varieties of the Calabacillo type.

When grown from seed, the selection should only be made after due examination of the interior of the bean, as the quality of the finished article can generally be determined by this means. The trees selected for seed bearers should be vigorous, healthy, of good form, and the blossoms should be efficiently protected from cross-fertilisation, or if deemed expedient the flowers themselves may be artificially fertilised. It would then be seen that the produce could be made to come true to a very high percentage, and once plantations of a single type could be brought into existence, their superiority would be so obvious that no further persuasion would be required to have the method generally adopted, as it would be seen to be the most profitable practice which could be pursued. Fields would then be arranged so as to produce a sample of one certain quality, showing no variation in the size and form of bean or the quality of its interior. It would be possible to have plantations on which not a single red pod could be found, and others on which not a single yellow one appeared.

How easily this result could be obtained by grafting is readily to be seen, and although perhaps slightly more lengthy and expensive, it is a preferable mode of propagation to that of raising from seed, and in the long run it would pay handsomely. There are excellent kinds in the fields, and if these were used for propagating purposes, and each distinct variety kept separate in the same way as in fruit farms, classes of cacao could be put upon the market having a distinct and regular value. Field names would be infinitely preferable to the names now used, as these latter are by their indefinite character quite useless for identification.

Trinidad Criollo is by general consent admitted to produce a high quality cacao and is known to be similar in character to that produced by the so-called Caracas variety, which is in reality Venezuelan Criollo. In a consular report on the agricultural conditions of Colombia, Consul Dickson mentions that "the variety chiefly grown in Colombia is different to that of Venezuela, which produces Caracas cacao, the pods being much larger and containing a greater number of beans, but as the number of pods produced by a tree is greater, it is probable that on the whole the Venezuelan variety is the more productive of the two. The quality of Colombian cacao is little, if at all, inferior to that of the Venezuelan, but it is little known in commerce, as only an insignificant amount is exported, the supply

scarcely satisfying the demand of the country." What this variety may be, we have no means of correctly ascertaining, but the description indicates that it is very near to, if not synonymous with Forastero, and it is to be noted that such a variety would clearly be "forastero" or foreign to the Caracas people, and may have been introduced to the West Indies and elsewhere *viâ* Venezuela.

The form known as Trinidad Criollo by us, is exactly represented by Dr. Preuss' figure of *Cundeamor legitimo* (Plate 2), and that known as Forastero is exactly that of Preuss' *Carupano grande,* and West Indian Calabacillo by his figure of the same variety. Wright's figures of Forastero are also in strict accord with the author's view of Forastero, with the exception that in Trinidad it more often takes on the bottle-necked form which characterises Criollo. It has, however, been frequently found that the interior quality of a pod cannot be judged by its exterior form and appearance, and hence the disappointing results of propagation by seed. Although the outside of two pods may be similar, yet it is possible for their contents to present a great contrast in quality, and therefore no reliable conclusions can be reached when judging cacao by the outside of the pods alone, and figures or outlines are of little use for the same purpose. A Calabacillo or Amelonado shaped pod may, when opened, show that its contents are in affinity with Criollo varieties, and suggest the intercrossing of those kinds, and *vice versâ;* and pods of the ideal shape of Trinidad or Nicaraguan Criollo may afford beans of a quality only to be compared with the commonest Calabacillo produce. It is seen, therefore, that the reliance hitherto placed upon the selection of pods for seed by outside characters is entirely unsupported and their use, for planting will clearly tend to deterioration in quality; this shows the high importance of adopting the processes of budding and grafting for the cacao field.

Sir L. A. A. De Verteuil, K.C.M.G., tells us in his work on Trinidad, 2nd ed., 1884, p. 241, that "from its first settlement, Trinidad exported cacao; and that cacao soon

gained a reputation on account of its delicious aroma. According to Gumilla, it was superior to that of Caracas and other places, so much so, that the crops were bought and paid for beforehand."

"In the year 1727, however, a terrible epidemic spread in the cacao plantations" and complete ruin followed. The nature of this epidemic is indicated, for Sir Louis states "the trees were apparently healthy and vigorous; the flowering abundant, giving fruits; but none of them came to maturity, as the young pods dried up before full growth." It is, of course, impossible to decide exactly what this disease really was, but the presence on the plantations to-day of diseases which might be similarly described, leads to the inference that it was of fungus origin, and similar to if not identical with some of those diseases recently identified.

"Thirty years later," Sir Louis De Verteuil continues, "some Aragonese Capuchin fathers were successful in their attempt to revive the culture of cacao in the island. They imported from the Continent a new species [variety], the *Cacao forastero,* which, though giving a produce fo inferior quality, was nevertheless promptly propagated as being hardier; that is the cacao at present cultivated in the island."

The characteristics of Trinidad Criollo cacao are, the thinness of the shell of the pod, its rounded beans, and pale colour of the interior of the bean on section. The leaves of the tree are small when compared with the Forastero varieties, and the tree itself is not nearly so sturdy and thriving, and does not produce such regular and abundant crops as the Forastero and Calabacillo varieties. The skin of the bean is thinner, and the interior has but little of that bitter flavour which is characteristic of the unfermented bean of Forastero and especially of that of Calabacillo.

The flattest beans are those produced by pods of the Calabacillo type. The beans of Forastero are intermediate between these and the rounded form of the Criollo, which are often slightly pointed. The sketch of beans of three typical varieties in Figs. 1, 2, and 3 on the opposite page

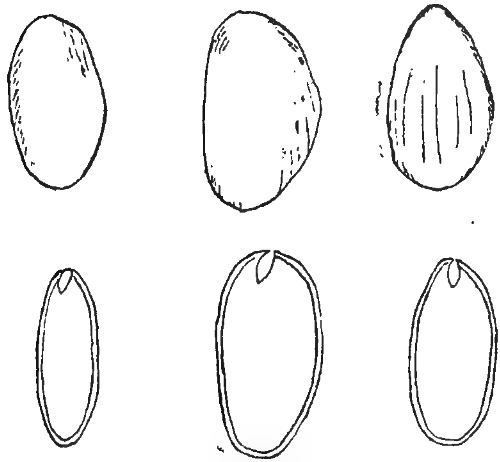

Fig. 1. Calabacillo. Fig. 2. Forastero. Fig. 3. Trinidad Criollo.

shows the difference in form which occurs, but there will be found intermediate forms hardly reconcilable with any

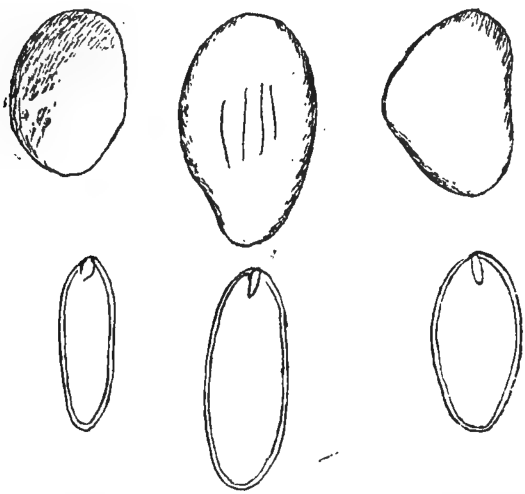

Fig. 4. Theobroma Bicolor. Fig. 5. Nicaraguan Criollo. Fig. 6. Venezuelan Criollo. Caracas Cacao.

The figures of different varieties of bean, as in "Cacao" (1900), by the author

of the figures, so that these must be taken merely as the type forms of the varieties mentioned.

Figs. 4, 5, and 6 represent respectively beans of Theobroma bicolor, Nicaraguan Criollo, and the best or high-priced variety of Venezuelan cacao sometimes called "Caracas." The Nicaraguan is the largest cacao bean I have seen, and is of the finest quality, only to be approached by the finest flavoured Criollo, or "Caracas," which is now called Venezuelan Criollo.

There are rounded beans* to be found in almost every pod towards its extremities, but the proportion of rounded beans in Calabacillo is very small indeed, and the yield of this form of bean increases only as the character of the pods approaches the Criollo type. Calabacillo gives small, rounded and smooth pods and flat beans, having a bitter taste and deep purple colour. It is the lowest type of cacao, and requires the greatest amount of skill during treatment to bring it into marketable form, the process of fermenting taking more than double the time required for Criollo. The tree, however, is the strongest grower and the hardiest of all the varieties.

In the best forms of Venezuelan and Trinidad cacao, the beans are characterised by a peculiar prominence on their sides (see Figs. 2 and 6).

Trees of the Forastero type are strong growers, and its varieties are therefore suitable for most lands in which cacao can reasonably be expected to thrive. It approaches the Calabacillo type by the Amelonado variety, both red and yellow, and certainly stands as a large intermediate and variable type between Criollo and Calabacillo. In general, Forastero has a thick skin. It approaches the Trinidad Criollo in form, or runs into it by its variety *Cundeamor veragusa,* red and yellow; but trees may be found bearing pods which are hardly to be distinguished from the Criollo on the one side and the Calabacillo on the other, showing the range of form covered.

* The word "bean" is incorrect, but as it is the common form of expression among cacao planters it is used as being better understood than any other.

The planter should ascertain the character of his land with as much accuracy as possible before deciding what variety of cacao he will plant. If very poor he can rely on Calabacillo only, if moderately rich Forastero, but on rich and lasting ground the best types may be planted. If, however, the best types were grafted on the strong-growing Calabacillo, there would be more probability of success in growing the best varieties on inferior as well as on rich soils.

The majority of plantations contain trees so mixed in character that it is difficult to separate one kind from another although it cannot be doubted that it would pay well for any extra trouble if a system of planting grafted trees of each type in separate fields were adopted.

In length the leaves of the Criollo type vary from 5 in. to 12 in. and from 2 in. to 4 in. in breadth. Forastero cacao gives the largest leaves of all, some recently examined being over 3 ft. in length. Special measurements of some growing in the Royal Botanic Gardens were made by the author, who found that they varied from 9 in. to 21 in. in length, and ranged from 2½ in. to 6 in. in width. The leaves of the Calabacillo type are shorter and wider in comparison with their length than either Criollo or Forastero. It must be understood, however, that these measurements are taken from extreme forms, and that the nearer the trees approach other varieties the nearer alike are the leaves.

Cacao is said to have been cultivated largely in Jamaica some two hundred years ago, but according to Long, in his "History of Jamaica," the plantations were destroyed by a "blast." Sir D. Morris mentions that in Trinidad also the trees were visited by a blast "sometime during the last century." He interprets the word "blast" as a "blow or hurricane," but the word has also another meaning. "Blast" is synonymous with "blight," and this is confirmed by Walker's Dictionary as follows: "To blast—to strike with some sudden plague." Either interpretation would however fully account for the destruction of plantations, especially when taken in conjunction with the

high rate of duty which was imposed on the article in England at about the same time. Whatever the cause, the cultivation of cacao in Jamaica received a wonderful check, for in 1671 Long states there were as many as sixty-five walks in bearing, while in 1882 cacao was only grown in isolated instances until the value of the product was brought into notice by Sir Daniel Morris when resident there in 1879–1886, when the cultivation largely increased. The introduction to Jamaica was probably effected by the Spaniards, as the English only came into possession of that island in 1655, sixteen years previous to the date mentioned. One species is mentioned by a writer (Martius) as having been found in Jamaica (*Theobroma sylvestris*), but the accuracy of this statement would appear to need confirmation.

The figures in Preuss' work are very instructive. It will be noted that the beans of the Nicaraguan Criollo are larger than those of any other kind shown, but the beans of *T. pentagona* equal if not exceed them in size, and are indiscriminately mixed with Criollo produce in Nicaragua. The cross-sections showing the interior spaces give the reason for their light weight in proportion to size. In other sections the compact form is shown, which renders those kinds heavier bulk for bulk than those with hollow centres. As a rule, however, the beans with hollow centres have the best "break" and the best colour and flavour on completion of the curing process.

Spon's Encyclopædia gives *Theobroma angustifolia, T. bicolor, T. guianensis, T. microcarpa, T. ovalifolia, T. speciosa, T. sylvestris* as producing commercial cacao, but we cannot learn upon what authority. When travelling in Central America in 1885, the author found *Theobroma bicolor* indigenous in the province of Veragua, United States of Colombia. It was known as "Tiger cacao," so named from the rank smell of the seeds. It is not in general use by the inhabitants, though it is said to be used in some manner by the Indians. It has also the name of "Indian chocolate" and "Wariba," the latter being the Indian

name, and appears to suggest some connection with the "Wari," or wild hog, probably a peccary (*Dicotyles*) which is known to emit from a gland on the back a strong-smelling fluid.

From information gathered when in Nicaragua, and from observations made on trees introduced by the author to Trinidad (which have fruited), it is certain that commercial cacao of fine quality is produced by *Theobroma pentagona,* the beans of which are nearly double the size of the average Trinidad bean.

Theobroma bicolor and *T. angustifolia* were unsuccessfully introduced to Jamaica in 1885, the seeds all failing, but in 1893 the author introduced into Trinidad *Theobroma bicolor, T. angustifolia, T. pentagona,* and the variety of Theobroma cacao known as Nicaraguan Criollo in considerable numbers, as growing plants. These trees have all produced fruit and have been widely distributed locally and to Ceylon and other places by the Botanical Department, the last to be propagated being *T. angustifolia* which only furnished fertile seeds in 1907, or fourteen years after introduction, the others having produced good seed several years ago. *Theobroma pentagona* promises to become a favourite with West Indian planters owing to the large size of its beans. From supplies sent by the author to Dominica, Mr. Jones, of the Botanic Station, has been very successful in grafting it upon stocks of Theobroma cacao. *Theobroma angustifolia* is a larger grower than any other known species, but it does not produce commercial cacao, and is only of botanical interest. The same may be said of *Theobroma bicolor.* So far, they have not been a success as stocks for the best kinds of commercial cacao, but they may prove suitable on further experiment. *Herrania albiflora* and *Pachira insignis* have both been sent to the author as "wild" cacao, but neither of these trees has anything in common with Theobroma cacao, and neither of them produces saleable samples.

According to Aublet's illustrations the pods of *Theobroma guianensis* are small and oval, distinctly marked with five

raised ribs, and the leaves are much like those of *T. cacao,* but more cordate at the base. The fruit of *T. sylvestris.* from a Plate by the same author is small, smooth, yet still showing the five divisions of the pod by slight depressions or lines on the outside at equal distances from each other. The leaves are small and suggestive of the ordinary form borne by "Criollo." The pod of *T. bicolor,* Humboldt, is woody in texture, hard and dry, and specimens can be kept for any length of time. There is a specimen, collected in Veragua in 1885, in the Herbarium of the Botanical Department of Trinidad, and also specimens of the leaves and flowers, and these have since been supplemented by specimens grown in the gardens where it is established.

FIG. 7. TRINIDAD CRIOLLO

FIG. 8. TRINIDAD FORASTERO VERAGUSO

TYPICAL VARIETIES OF THEOBROMA CACAO

The Figures, which are reproduced from photographs by Jacobson of Trinidad, are about one-third of the actual size. The Pods were selected from average specimens.

CHAPTER II

SOME ILLUSTRATIONS OF PODS

THE illustrations facing pages 14, 16, and on page 17 show several typical varieties of the well-known Theobroma cacao, namely, Trinidad Criollo (Fig. 7); Trinidad Forastero (Fig. 8); Trinidad Amelonado (Fig. 9); Trinidad Calabacillo (Fig. 10); Venezuelan Criollo (Fig. 11); and Nicaraguan Criollo (Fig. 12). The pods of three other distinct species are seen in Fig. 13, *Theobroma pentagona,* or Alligator Cacao; Fig. 14. *Theobroma bicolor,* or Tiger or Wariba Cacao; and Fig. 15. *Theobroma angustifolia,* or Mono or Monkey Cacao.

Fig. 7. TRINIDAD CRIOLLO is a form of Theobroma Cacao, showing a distinct " bottle-necked " pod, rounded oblong beans having a white or straw-coloured interior, outer walls of the pods thin and easily penetrated, and colour either red or yellow.*

Fig. 8. TRINIDAD FORASTERO VERAGUSO is to be taken as showing the Trinidad type. There is a large amount of variation in form, grading from Criollo on the one hand to Amelonado on the other. Some forms are known having the pod walls over an inch in thickness while others approach the Criollo type of thin-skinned pods, and take on to a small degree the bottle-necked form usual in that variety.

Fig. 9. TRINIDAD FORASTERO AMELONADO in the downward scale, is intermediate between the first type of Forastero (Fig. 8) and Calabacillo. Some of the trees carrying this shape of pod afford cacao of fine quality, and the variety is largely grown in the West Indies. The trees of

* Pods of Forastero often assume this form, but show thicker walls of the pod;

and near this type are, as a rule, vigorous in growth and good croppers.

Fig. 10. Trinidad Calabacillo.—This is the lowest form of Theobroma cacao cultivated in the West Indies. Its beans are flat, solid, generally dark coloured, strong flavoured and have a " cheesy " break. The illustration shows an extreme form, but the pod is usually more rounded at its extremity. Forms are abundant connecting this with *Forastero amelonado* and *amelonado* with *veragusa* (Figs. 9 and 8).

Fig. 11. Venezuelan Criollo or Caracas.—This variety has in general a high-shouldered pod, and in form sometimes approaches near to var. *amelonado,* from which it can, however, be easily distinguished by the colour, shape, and size of the beans. In some forms a little of the bottle-neck form may be detected.

Fig. 12. Nicaraguan Criollo has also a high-shouldered pod, beans of large size, and light interior when cut, which dries to a fine cinnamon colour when properly cured. The interior of the cured bean is hollow, and it is of light weight in accordance with its size. Pods, as a rule, are pointed at the extremity but not always. Wright's illustrations correctly represent them as they appear in Nicaragua, where the variety was collected by the author in 1893, and introduced to Trinidad, from whence it was distributed to Ceylon and various West Indian stations. Variation in the pods of the innumerable forms coming under the specific name of Theobroma cacao is so wide, that the divisions could be extended to an almost indefinite length. Local names are valueless as a rule; each district, and in some cases each individual planter, has his own names for the various forms. In some cases they agree; in most, the nomenclature is confusing through the number of names given to one form. It is to be noted, however, that where a particular form is introduced and planted on a fairly large scale, whatever the minor differences, there is generally evidence of the preponderating form clearly apparent in produce sent to market, as revealed by

FIG. 9. TRINIDAD FORASTERO AMELONADO

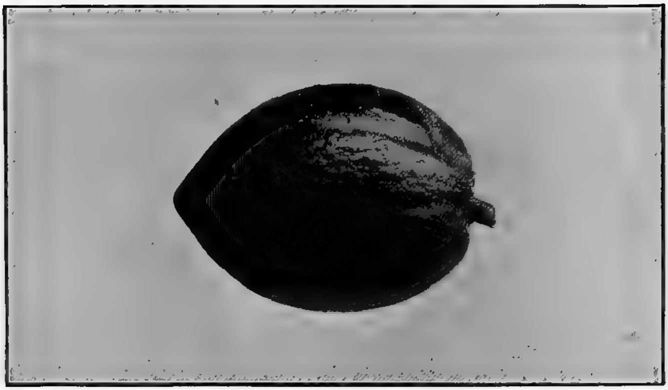

Fig. 10. TRINIDAD CALABACILLO

FIG. 11. VENEZUELAN CRIOLLO OR CARACAS

TYPICAL VARIETIES OF THEOBROMA CACAO (*continued*)

Figures 9–11 are about one-third of the actual size, and Figure 10 is rather less. The Pods were selected from average specimens.

prices obtained where selected strains have been largely planted.

Fig. 13. THEOBROMA PENTAGONA, or "Alligator Cacao," has, as its scientific name denotes, five distinctly raised acute angled ribs on the surface of its pod, between which lies a peculiar warted surface, which is likened to the skin of an alligator; hence its common name in Central America. The outer covering is soft and easily penetrated, and when ripe it readily bursts on falling to the ground. The beans possess a high flavour, and when cured, a fine aroma, and are larger than any of the various forms of Theobroma cacao, except perhaps those of Fig. 12, "Nicaraguan

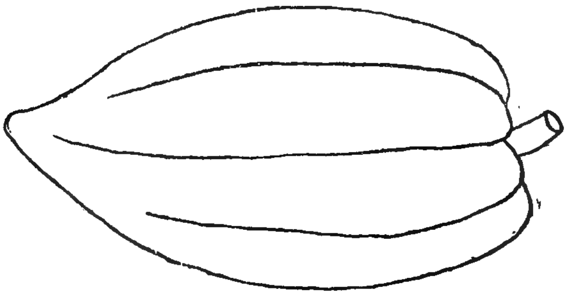

FIG. 12.—Nicaraguan Criollo.

Criollo," with which they compare. In the author's opinion, however, it is probable that "Nicaraguan Criollo" may have hybridised with *T. pentagona*, causing increased size and alteration in form of the beans in the Criollo, a point which future observations will probably decide. The pod of this species is universally dull yellow, sometimes with a dark or reddish touch of colour on the side next the sun. Wright's figure of this species is shown a little too small, but that given by Preuss is an excellent representation of the species, which affords commercial cacao of the highest quality.

Fig. 14. THEOBROMA BICOLOR, or Tiger, or Pataste Cacao.—The specific name *bicolor* is given owing to the two colours of its leaf, the upper surface showing a dark green, while the under has a grey or whitish appearance. The

pod is oval, hard, woody and half an inch or more in thickness, with finely reticulated riblike carvings on the exterior fruit wall or shell of the pod. It requires a saw or other cutting instrument to open the pod, but it cracks and bursts readily if forcibly cast upon the ground or other hard surface. The beans are flat, oval, and covered with a fibrous yellow pulp having a strong odour. When deprived of its outer skin and roasted, the bean may be used in the same way as almonds, and boiled to sweetstuff with sugar. The interior of the bean is perfectly white and solid. It has no pronounced flavour or commercial value.

Fig. 15. THEOBROMA ANGUSTIFOLIA, otherwise Monkey Cacao or Cacao Mono grows to a larger sized tree than any other species under mention, the author having seen trees 40 ft. in height, possessing stems a foot to 15 in. in diameter. It is of no known economic value at present, but was introduced with *T. bicolor* and *T. pentagona* in 1893, in the hope that it might prove useful as a stock on which to graft the commercial form. This, however, has not yet been tried, owing to the want of sufficient seedlings for the purpose.

The botanical details of *Theobroma pentagona, T. bicolor*, and *T. angustifolia* are well given in the illustrations of Preuss' very well-known work, published by Kolonial-Wirtschaftliches Komitee, 1901, Berlin, Unter den Linden 40, which should be referred to by those interested in the botany of these species. To the cacao planter it will be sufficient to say that the latter-named species, Figs. 13, 14, and 15, carry certain specific distinctions which clearly and distinctly separate them from any of the forms of Theobroma cacao from which the main crop of commercial cacao is derived.

The nearest allied species to Theobroma cacao is *T. pentagona*. The latter resembles the former in character of its leaves and habit of growth so closely as to make it difficult to distinguish between them, except when in flower or fruit. The evidence in favour of the affinity of the two species is strongly supported by the fact that seed-

FIG. 13. THEOBROMA PENTAGONA

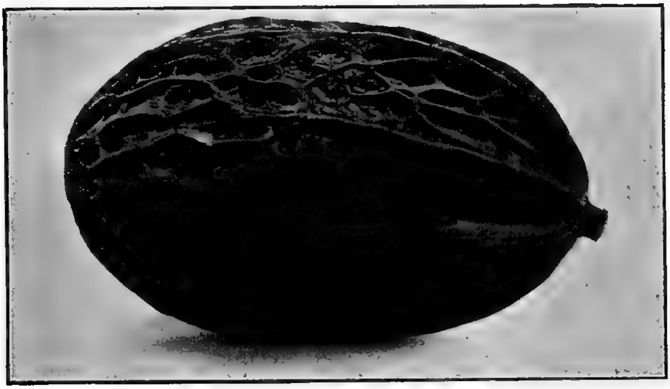

FIG. 14. THEOBROMA BICOLOR

FIG. 15. THEOBROMA ANGUSTIFOLIA

SPECIES OF THEOBROMA
DISTINCT FROM THEOBROMA CACAO

lings of Theobroma cacao make excellent stocks on which *Theobroma pentagona* can readily be grafted, and it is strongly suspected that the two species readily hybridise one with the other, but this has not as yet been proved by actual experiment.

It is generally accepted that the principal supply of commercial cacao is derived from two species, viz., *Theobroma cacao* and *Theobroma pentagona,* while *Theobroma bicolor* and *Theobroma angustifolia* do not produce cacao of commercial value. The evidence is not strong whether any of the other species, *Theobroma sylvestris, T. guianensis, T. ovalifolia, T. speciosa, T. microcarpa,* &c., can properly be included as producing commercial cacao ; but if it is found that they do, it is probable that a proper botanical study of their characters will show their close affinity with our well-known *Theobroma cacao,* or they may prove to be merely varieties of that species hitherto included under separate specific names.

Wright, at page 30 of his second edition, says, speaking of the varieties of Theobroma cacao, " The mixed nature of the varieties now cultivated is manifest," a statement in which the writer entirely concurs, having noted, as mentioned in previous pages and elsewhere, that the varieties of Theobroma cacao now form " a heterogeneous mixture of cross-bred varieties " from which a list of one hundred or more varieties could easily be arranged, including all the varieties with special names, and showing gradual passage from one form to another. I have before me now a list of thirty varieties as grown on the estate of a well-known Trinidad planter. The differences between many of these is so slight that, while recognisable to the sight, to describe them in writing is an impossible task.

Wright also refers to the work on the *Sterculiacea* of Brazil by Schuman, who is said to have described numerous species of Theobroma, including two not mentioned in our list, viz., *T. grandiflorum* and *T. incanum.*

The variation in colour of the pods of Theobroma cacao and its varieties is very wide, but colour is of little

value as a distinction, it having been frequently proved that a red pod will produce trees bearing yellow pods, and that a yellow pod will produce trees bearing red pods, a fact proved by actual experiment carried out from 1898 to 1908 by the Botanical Department of Trinidad.

The "colour" of the interior of the cacao "bean" when mature and well cured is one of the best indications of its value on the market. Following this is "aroma," which, although fully appreciated by buyers and sellers, cannot be described in writing. Next in order comes "break," which means the appearance of the interior of the bean when cured. When the interior is easily disintegrated or crumbles easily on pressure, it is said to have a good "break"; while "cheesiness," or softness and want of friability, is the antithesis of "break," and, when present, lowers the value of a sample, as it shows either a want of careful preparation, careless picking of unripe fruit or inherently bad quality in the class of bean. A good "break," as a rule, follows the depth of colour of the interior of the bean, the light being the better, the darker the more inferior, a point which is accentuated by the fact that cacao in recent years is always tested by taking a percentage of the sample and making a close examination of the interior of the beans by cutting both longitudinal and cross-sections, thus enabling lots to be graded easily in bulk both in store and factory.

The manner of pollination of cacao is not well known, and studies were instituted by the author at the Government experiment station some months previous to his retirement in June 1908, with a view to making a complete examination into the means by which it is effected. This study, however, was not complete in full, but the inference to be drawn from observations made is that fertilisation or pollination is effected by means of several kinds of minute insects. Wright in his work records (p. 23) that Dr. Uzel carried out experiments in Ceylon, which led him to the conclusion that "cacao flowers were pollinated solely by thrips, and that these insects occurred in the

largest numbers where trees were exposed to sunlight, or where flowers were thus exposed by the pollarding of the branches of the cacao-trees. Isolated cacao-trees do bear large crops, but this may be due to the increased or unlimited food-supply available to such specimens, as well as to the increase in the number of pollinating insects."

In Trinidad generally there are at present few or no "thrips" on cacao, so that pollination cannot be dependent on that class of insect alone, or there would be no cacao. If the "mortel" shade were to be removed as has been proposed, "thrips" would probably increase. Wright also mentions that Green (entomologist) has recorded in Ceylon the occurrence of thirty specimens of a common aphis (*Ceylonia theæecola, Buckt*) in a cacao flower, each being dusted with numerous pollen grains. The flower itself is so formed that it appears almost impossible for pollination to be effected without some extraneous aid, and to the present time the evidence appears strongly in favour of the view that pollination is accomplished by the aid of minute insects, thrips, aphis, &c., and so far as it goes confirms the correctness of our incomplete investigation. To ascertain correctly the means by which cacao is in general fertilised would require the undivided study of a biologist for a very lengthy period. In the West Indies little trouble is felt at any want of effective pollination as fertilisation is regularly effected in proportion to the flowers that appear, unless abnormal weather occurs, in extremes of drought or rainfall; either of which will cause a dropping of the pod, even after full pollination has been effected.

CHAPTER III

SELECTION OF LAND

It is for the prospective planter who contemplates starting in a colony which offers both cultivated and uncultivated or forest lands, to determine which he will choose for his operations. Immigrant planters sometimes arrive in the tropics with vague views of what they are going to do, some having an exaggerated idea of their own skill and importance; while others, less confident, show an inquiring nature, are not hasty, and endeavour to see for themselves what class of property will best suit their purpose and resources. In the West Indies generally there is little virgin land suitable for cacao now remaining, but in Trinidad there is land available of every class, and also a small quantity in Dominica. There is usually plenty of "ruinate" or abandoned land on offer, and the colonist has, therefore, considerable choice before him. He can either buy a going concern or he can buy other land and make his own estate.

If the investor has no previous experience of cacao-planting he should seek the advice of some capable expert in order to enable him to judge between the different lands which may be offered to him.

In the usual course of business, small and large estates are constantly passing through the market, and the price of these varies according to the locality in which they are situated and the quality of the land. The value of an estate is usually estimated at per tree, or per 1000 trees, and not at per acre, and what might be worth in some districts but sixty cents would in other and celebrated districts be worth as much as $2 or 8*s*. 4*d*. per tree.

The best course for the intending investor to adopt is to make himself acquainted with the several districts and await his opportunity, residing in the colony and adding to his experience in the meantime. In Trinidad, as everywhere else, there are those present who will not hesitate to recommend estates to buyers simply for the commission they could get from the seller, and there are others again who will accompany an intending buyer in a friendly way on a visit to an estate and afterwards attempt to recover an exorbitant fee for their services. Let the investor beware of such or he will probably be landed in a similar plight to that of Mark Tapley, but it is questionable whether there would be " any credit in being jolly " under such circumstances. Good estates have to be waited for, and are always readily disposed of, so that the buyer should quickly make up his mind when he sees " a thing going " which is fairly in accord with his ideas.

To buy forest land and make his own estate is a hard task for a stranger, and one in which the new-comer is seldom successful. After many years of experience, the author suggests that it is preferable to let those do the pioneering work, who, from a better knowledge of the colony, are able to work with greater economy; and to buy an estate, partially or fully established, near to lands which may be purchased later for extension. Such estate should not be too large, as it is better to begin with a medium area than with a large estate which is expensive in its working. Many seek to buy lands in the vicinity of a number of small owners buying small additions as they fall upon the market.

If, however, the planter buys an established estate, he of course inherits all the mistakes of his predecessor, but it is highly probable that, except under special advice, his own mistakes would be quite as many as he could possibly inherit. Inherited mistakes would probably include injuries due to pruning, bad drainage, too close or too wide planting, insufficient or too heavy shading, &c.; but these drawbacks are not entirely to the planter's disadvantage,

as to correct them will afford him valuable experience, especially if the work is carried on under reliable advice as to what should be done to bring the estate under a correct and scientific agricultural *régime.* It is highly necessary that the planter should know, for instance, how to apply correct treatment to badly wounded trees; and he cannot do better than learn it well under proper guidance on his own estate.

In no way is it suggested that the planter should purchase an estate in which many drawbacks appear, but rather, that he should not refuse a fairly advantageous offer where they do appear, other points being favourable.

It is important to carefully ascertain the character and quality of the soil, and for this purpose samples should be taken and submitted to careful mechanical and chemical analysis, both qualitative and quantitative. It would nevertheless be a grave error to assume that land fit for the cultivation of cacao could be chosen by the results of chemical analysis alone, for it is quite possible for land to contain all the substances required for the growth of a particular plant, and yet be totally unsuited to grow that plant, owing to the materials being present in a form which cannot be taken up by the roots.

Sometimes the mechanical nature of the soil is quite as important as its chemical constituents, and unless a mechanical as well as a chemical analysis is made, its suitability for the purpose cannot readily be ascertained. Although these drawbacks exist, yet chemical analysis is very useful, in fact essential, in securing a right judgment on the suitability of land for any particular crop, but taken alone it cannot be trusted. Whenever used, samples should be taken with the greatest care from those parts of the land which would give a fair average of the area under examination. Unless this is done, chemical analysis is not alone useless, but becomes positively misleading. For instance, a planter takes a sample of soil from his field, and brings it for analysis; the chemist tells him it is good and, rich in various constituents and excellent for the

crop he proposes to plant. In faith of this the planter buys and plants, alas! with failure. Why? The sample was taken from a spot which contained or received the wash of the surrounding land, and was in consequence as rich in proportion, as the adjoining ground was poor and valueless. Chemical analysis is a valuable adjunct to practical planting experience, but, without that experience, leads the planter into frequent dilemmas. A mechanical analysis can easily be made by the planter himself after a short course of suitable instruction.

Johnston, a well-known agricultural writer, has the following in his "Elements of Agricultural Chemistry" (17th ed., p. 147): "Chemical analysis of a soil as ordinarily conducted, valuable though it is in some respects, is not of much service in indicating the actual fertilising matters at the moment available in the soil. The agencies at work whereby the elements of fertility are rendered available for the plants' use, are so complicated and numerous that *the best test of a soil's fertility* is to carry out experiments with the plant itself." There can be no doubt of the truth of this extract, which is also supported in the writings of the great French chemist Lille, who advised that a planter should analyse a soil by the plants he can grow upon it. The point is emphasised here to guard the planter against advisers who in every country are found ready to persuade the inexperienced to buy on the results of chemical analysis of the soil alone.

The soil chosen should be one, as Wright puts it (p. 140), having good physical and chemical properties," and he agrees with Jumelle in pointing out that "the best cacao soils are those which have not been cultivated for many years or not at all, and that abundance of humus, 1–2 per cent. lime, 0·25 per cent. of phosphoric acid, as well as abundant supplies of other ingredients, are necessary before one can hope to obtain the best results." A shallow soil resting upon hard bed-rock is totally unsuitable, while a moderately shallow soil resting upon a friable rock is often found to grow cacao to perfection. It is generally

considered among Trinidad planters that a loose clay, or clay with an admixture of a fair proportion of sand and lime is favourable to the growth of cacao. If the soil is covered with a vegetable deposit, *humus*, which has accumulated from the falling leaves and branches of the original forest, so much the better. If land can be found on the banks of a stream or river where there is considerable depth of alluvial deposit, such a position, if capable of being well drained, is a sure source of wealth to the cacao planter. Hard, dry, rocky soils, stiff clays, mountain-sides where great detrition frequently takes place, shallow sands and boggy ground, should be carefully avoided. The aspect of the land should always be very carefully considered. A site exposed to trade or prevailing winds, or to strong sea breezes, should not on any account be chosen for a cacao plantation. Land which has been previously cultivated with other crops may be chosen when it has good depth, is easily drained, and is capable of being improved by the application of suitable manures, but "thrown out," "ruinate," or abandoned lands should be taken up with the greatest caution. Worn-out sugar lands are dangerous investments for the intending cacao planter as a rule, but an intelligent choice even here, by men who are acquainted with the local character of the soil and the cacao-tree and its requirements, will often result in the development of a productive plantation. Salt is inimical to the growth of the cacao-tree, and lands liable to be inundated with tidal waters should never be purchased.

Shelter belts of timber should be left on the windward side of a plantation when it is being made from the original forest, and on established estates it would be found economical and convenient to cultivate to windward such timber trees as will form good "wind breaks," while, at the same time, they will grow into and afford ample material for the erection and repair of suitable buildings for residences, and for the purpose of curing and storing the crop.

"Cedar" (*Cedrela odorata*), West Indian mahogany

(*Swietenia mahogani*) and its relative *Swietenia macrophylla,* or the mahogany of Central America, which grows faster and produces a lighter-coloured wood than the West Indian ; Balata (*Mimusops globosa*), " Purple Heart " or *Peltogyne ;* " Poui " or *Tabebuia ;* are, with several others, suitable trees for cultivation.

In Central America the " mango " is largely used for shelter belts. The seeds are sown in shallow, straight trenches on the boundary lines on windy sides of plantations. The trees are allowed to grow together a foot to eighteen inches apart and are kept trimmed in hedge form on either side, but are topped to make them bushy below, and then allowed to grow to their full height. They form the most effective wind screen known. A careful study of the trees growing upon forest lands will often afford the intending planter a fair guide as to what forest land will produce. A soil producing nothing but scrubby original growth can hardly be expected to produce good cacao, and in fact never does. Sometimes, however, land covered with heavy timber is found quite unsuitable for cacao cultivation, but this is the exception rather than the rule, and much must depend upon the planter's own faculty for observing surrounding conditions, whether a successful choice will eventually be made.

In tropical countries the agriculturist is, in general, conversant with the names of indigenous trees which denote a soil suitable for cacao, but this, of course, is only of service where virgin land is selected.

A planter strange to the country in which he proposes to settle should never choose a site, or buy properties, until he has resided on the land for a sufficient length of time to enable him to be capable of forming a correct judgment from his own special observation, as well as from the reports of other persons.

An ideal spot on which to found a cacao plantation is a well-sheltered vale, protected by mountain spurs from the prevailing winds, well-watered, and yet well drained, with a good depth of alluvial soil on which rests a thick deposit

of decayed vegetable matter, easy of access, and in a district distant from lagoons or marshes for the sake of the proprietor's health. Such a spot in a climate similar to Trinidad could not fail to produce regular crops of the finest quality of cacao.

Elevation above sea-level has also to be considered in choosing ground for planting cacao. The higher the elevation the lower the degree of temperature experienced, and the trees make smaller growth and give less in annual produce.

Plantations existing at 800 ft. to 1000 ft. above sea-level in Trinidad are few and far between, and cannot take rank among first-class estates.

The mean annual temperature of Trinidad (which is admittedly in the first rank of cacao-producing countries) at 50 ft. to 100 ft. above sea-level is found to be 78·5° Fahr., from a record of twenty years' observations. The mean annual relative humidity is 79°, and it has a rainfall per annum of 66·6 in. The average rainfall of the island, calculated on returns from over one hundred stations, is 72·39 in., and it is certain that the relative humidity in many districts is higher than at the station only 100 ft. above sea-level. The island rainfall Table shows falls as high as 124 in. per annum in the more humid districts, while coast stations on the western side of the island show falls of under 50 in.

Cacao planting is chiefly carried on below the thousand feet limit. Glaishier shows in his tables that temperature decreases some 3·2° Fahr. per 1000 ft. upwards from sea-level, from which it will be seen that the mean annual temperature suitable for cacao lies between 75·3° and 78·5° Fahr. It may therefore be gathered that planting cacao at high elevations is not a measure of good practice or economy, unless in specially favoured situations as regards soil and exposure.

The chemical composition of soils suitable for cacao will be given in the chapter on the Chemistry of Cacao.

CHAPTER IV

NURSERIES

THE cacao-tree has been propagated in the past almost invariably from seed. In the Annual Report for 1898 of the Botanical Department of Trinidad, the writer put on record (probably for the first time) the success of an experiment in grafting by approach, which had been carried out during that year. Although cacao is still for the greater part propagated by seeds, the advantages of planting grafted supplies from selected trees has made considerable progress, and the practice is now becoming recognised and recommended by many who have witnessed its successful adoption.* For those, however, who still prefer propagation by seed, or those who are unable to take up grafting for want of skilled assistance, the best methods of selection and practice are briefly detailed.

In making his selection of seed, the planter should not be guided by the colour, shape, or size of the pods, as it has been found that the variations are so numerous as to make such a selection utterly unreliable. He should carefully examine the trees on his estate and select those as seed-bearers which show such good qualities as: (1) high vitality and vigour; (2) good habit of growth; (3) good and regular bearing qualities, and (4) affording high-class produce. The trees should be marked and numbered, and only the best pods should be used for nursery work. The seedlings raised from the individual trees should be kept apart from each other. The young plants from each tree should be planted in rows and

* See article by Professor Labroy in *Journal D'Agriculture Tropicale*, October 1909, No. 100, p. 292.

properly labelled, so that the results may be observed and recorded. It must be mentioned here that seed selected from trees standing in a plantation near to inferior kinds will in all probability show a wide range of variation, but not nearly so large as would a selection taken from a heap in the field, without a knowledge of either of the parent trees. By methods described above, the maternal parent is known, and further supplies can be obtained from those trees which show most successful results. In any case, some inferior seedlings are sure to appear, but the maternal strain will assuredly be the most prominent, and the result will be better than if the seed had been taken from pods selected from their outer appearance only.

To give the planter definite information as to the actual quality of the produce obtained from his trees selected as seed bearers he should collect a certain amount of crop from each tree, place it for fermentation in muslin bags labelled with wooden labels having numbers cut upon them, and then place them together with his main crop in the "sweat boxes," so as to afford them the usual fermentation. This finished, the samples should be properly cured and finished separately, and the produce of each tree examined and recorded. This will afford him valuable information as to the quality of the tree he has taken as a seed-bearer, and if the produce from any tree does not show high quality he should discard it, and repeat the experiment on the same lines until he secures a set of seed-bearing trees which produce beans of the highest quality. This method should also be adopted when selecting trees for grafting purposes, as it is certain that each grafted tree can be propagated to an indefinite extent, and will produce cacao identical with that borne by the tree from which the grafts or scions are taken. Selected trees should receive definite names or numbers, under which their produce can be recognised and dealt with. Thus, we can readily obtain fields, say, of Suttons' "Conqueror" Cacao; Jones' "Wonder" Cacao; or Warner's "Choice" Cacao, &c.; and the produce of each kind can be planted in separate

fields, and marketed in places where the different qualities are in best demand, as is done with the fruits of Europe and America. The system recommended is merely that which has been in use from time immemorial among the vineyards and orchards of the world, and the sooner it is generally introduced and adopted by the cacao planters the better it will be for both grower and manufacturer.

Under seed propagation desirable trees *cannot be perpetuated,* as seed from them will not produce progeny true to the tree from which it was taken. Under the grafting process any desirable kind can be propagated and perpetuated, by the million if desirable, and every tree will give fruit identical with that of its parent. Whole estates might be planted with a single kind, which would give produce indistinguishable in quality, comparing one tree with another, while under seed propagation, the produce of two trees is *never alike.*

Seeds may be sown in beds made up of light vegetable mould, mixed with about 15 per cent. of clean river sand, or they may be sown in well-drained boxes in the same class of soil and afterwards placed in beds, to grow on for final planting. In places where transit is difficult, they may be grown in the joints of large bamboo stems cut to flower-pot size, or placed in open-worked baskets of split bamboo, which can readily be manufactured at a cheap rate. The basket is clearly better than the bamboo pot, as, in the latter, if allowed to stand too long, the roots take a curl which materially hinders growth when planted in the field.

When planting from seed, however, it is well known that the produce varies, and no two trees can be depended upon to give pods of the same size, or beans of the same size, colour, or quality. When selecting pods for seed, it is clear that, if taken from the open field, only the maternal parent of the seeds contained therein can be known, as the interminable varieties which everywhere exist clearly prove that cross-fertilisation readily takes place. Variation is also to be well seen in the cured

produce, for although the beans may have a common or family likeness, all dealers know, that if cut through and carefully examined, there are material points of distinction, and few can be found exactly alike in colour, break, or aroma.

It is this fact which causes difference in samples. A district or country may possess a certain original or predominant strain which places its produce when in bulk under a certain class; and although there may be as it were a family likeness, there will still be wide differences in the produce of individual trees. In the end, with reproduction from seed, unless it be carried out under scientific guidance, and unless the proper means for obtaining the best strains by selection are adopted, hybridisation and cross-breeding will inevitably result in gradual deterioration of the quality of the marketable produce of any country.

The difference which an "even sample" would make to the seller is obvious. We know that it can only be obtained by means of grafting and budding from selected trees, or, as some would call it, by vegetative reproduction, in contradistinction to seminal reproduction. It is clear that once a tree has been selected and largely propagated, owing to the possession of superlative qualities, the produce of that tree must be of an even character, and that, taken year by year, the crop will vary but very little in general quality. By using the process of grafting, the planter will be able to secure trees of one habit, pods of one colour, and beans of the very best quality. Such beans, when cured, would be unique in "break" and general condition, and would be immensely superior to any produce harvested from seedling trees. To adopt grafting as a regular practice upon a cacao estate would be to adopt a method the benefit of which has been proved ages ago to the agricultural and horticultural world.

The practice of grafting and budding cacao is, however, steadily making its way, the latter process being advocated by some as preferable to grafting. There is no difficulty in either process to deter or frighten planters either on the

score of expense or of time; and it is confidently expected that in the very near future these processes will be generally adopted as one of the necessary operations of every well-managed cacao estate. There is one point on which it is necessary, in Trinidad, to caution planters adopting these practices. They should take care that they fully understand the meaning and the details of the practice. Unfortunately, there are many persons who understand that the mere act of grafting improves or makes better the quality of the fruit of the grafted tree. Such should learn that grafting has no such effect, and that the process is one which merely perpetuates or increases the numbers of any special kind of tree, the quality of which is desirable and already known. It may appear strange to some readers that such opinions are prevalent in Trinidad, but they exist among even the better classes, and as they may exist elsewhere, attention has been directed to the fact.

With areas planted exclusively with selected varieties propagated by grafting, a proprietor would be able to manufacture cacao samples of the highest quality. It would be in his power to grow trees producing a high-coloured cacao, a cacao with a fine break, a cacao with fine aroma and flavour, or a cacao which is known as having "body" or weight; all of which qualities are in demand by the manufacturer in making his blends of the finished article of "cocoa" powder or chocolates.

Budding and grafting are not in any way expensive operations, and should in a very short time fully compensate for extras which may be incurred by their use, as the advantages are so apparent that, once understood, no one could be found to deny their importance and value. The methods are simple in the extreme, and have been readily learned by the younger members of the labouring staff in the Botanical Departments of Trinidad and many other colonies, so that competent workmen are available for estates.

CHAPTER V

PLANTING CACAO

THE preparation of virgin land for planting cacao is heavy work, especially if it is covered with a full growth of timber. In the West Indies such work is usually done by contract, at per acre, or per " quarrée " (in Trinidad), the latter being a Spanish measure of $3\frac{1}{5}$ acres. The cost of felling and burning varies in accordance with the prices of labour ruling in the district, from about $15 to $25 per quarrée.

Making provision for supply of young plants of a suitable kind is, of course, one of the first things to be considered in planting an estate, and it must be decided (*a*) whether to plant " at stake," which means planting seeds direct into the ground in the position the permanent tree is intended to occupy; (*b*) whether to raise the seedling plants in nurseries, in beds, boxes, or pots, and afterwards plant in the fields, or (*c*) whether to depend upon seedlings, and plant only grafted plants taken from selected stock.

Planting " at stake " means, that the young plant once fairly started does not have its roots injured in any way by the operation of transplanting, and the roots will once and for all assume a natural position. There can be no doubt whatever that by this method trees once well started have a great advantage over transplanted ones. Sometimes, however, it is more convenient or economical for the planter to raise his plants in nurseries, transplanting to the field in suitable weather. Advantages lie with both systems, and either may be used at will.

In nurseries, beds should be formed of light, friable soil, with a small admixture of sand. No manure should be

used in seed beds as it is not required, and plants grow much hardier without it. Where plants have to be transported to places difficult of access, it is better to grow them first in shallow seed boxes, and while the plants are quite small to transfer them to bamboo joints or baskets, and to grow on in these until plants are ready for the field. Plants should not be allowed to stand in bamboo joints long enough to allow their roots to curl or become matted, as this materially affects their subsequent welfare in the field. Plants may also be transferred to bamboo joints from beds and grown on for the fields.

When using nursery plants, the soil at the place of planting should be well prepared by breaking it up with a fork some little time previous to the day of planting in order to allow it to sweeten before the plant is put in.

The field is generally lined throughout, forming rows at certain distances, and pickets or stakes are placed in the ground showing the position of each tree. When seed is used, three selected seeds should be placed in a triangle about six inches apart and covered with about an inch of soil, the earth being pressed somewhat firmly down with the hand or foot, thus ensuring a more regular amount of moisture around the seed than if the earth were left loose. In transplanting from nurseries to the field the greatest care should be taken to keep the roots of the plants as free from injury as possible and to secure balls of earth to each plant. The roots must not in any case be allowed to become dry, and to secure a good supply of moisture in the plant itself, nurseries should always be copiously watered the evening before the plants are to be removed to the field. In no case should the plants, root, or branch, be exposed to a current of dry air or to direct sunshine.

In putting the plant into the ground the planter should make sure that he does not plant it too deep or too shallow. The surrounding soil at the time of planting should be pressed firmly down, but not made hard, allowance being made for dry or wet weather, but plants should never be

put in the ground, if it can possibly be avoided, when the ground is in an extremely sodden condition.

It is impossible, however, to instruct in full by writing how a plant should be placed or planted, and one practical demonstration is worth ten pages of letterpress. The novice should, therefore, seek from the practical experience of others, the requisite knowledge for the purpose.

The distance which cacao-trees should be planted apart will be determined by the planter in accordance with the character of the soil, the elevation above sea-level, and the slope of the ground. The higher above sea-level, and the poorer the soil, the closer the trees may be planted, and *vice versâ*—a distance ranging from 12 to 15 ft. apart each way will probably meet all requirements, *i.e.* 12 ft. in poor soil and 15 ft. in rich soil. Some have planted 18 ft. apart in extremely rich soil.

In the island of Grenada the practice of close planting is followed much more generally than in Trinidad, but successful planters are to be found among those who follow each system. The wide-planting cultivator says he gets more fruit per tree and fruit of better quality than the close-planting cultivator; while the latter claims to get as much or more per acre from his trees than the former does, and as good in quality. Probably more depends upon the judgment of the individual planter with regard to the character of the soil he is working, than upon anything else. If it is poor, he will plant close; if rich and deep, he will regulate his planting accordingly. It is not to be doubted, however, that, where practicable, wide planting gives the advantage of affording easier access to the cultivator for the various operations of pruning, harvesting, manuring, weeding, &c., and the plantations where the practice is carried out certainly assume a much better appearance and are better ventilated than those which are crowded with trees. The supplying of vacancies should be carried on during suitable weather, the aim being to obtain a field showing trees of regular size throughout.

The preceding notes on planting will apply to grafted or budded plants as well as to seedlings, but the former will require more care than the latter, and as soon as the planting is finished the young trees should each be supported by a strong, pointed stake, placed firmly into the ground close to the plant and safely tied thereto, in order to protect the point of union between the " scion " * and the " stock." † This is a weak part of the plant for a time, and close attention should be given in order to see that no strain or injury of any kind be brought upon it by wind or other cause.

Great care should be taken to remove as fast as they appear any shoots (*chupons*) which start below the union of scion and stock. If they are not removed, the character obtained by grafting is absolutely lost, and the tree will take on the character of the " stock " only. This arises from the fact that in many cases shoots below the graft start and outgrow the budded or grafted head, and take away from it the nourishment it would otherwise receive, causing it to become gradually starved and killed out. If these growths are removed, the sap is directed into the scion, and growth takes place, which will form a tree the exact duplicate of that from which the scion was taken.

Fig. 16, for which the writer is indebted to Dr. Francis Watts, shows *Theobroma pentagona* grafted on stocks of Theobroma cacao, grown by Mr. Joseph Jones at the Dominica Botanic Station. A paper read at the West Indian Conference of 1908 in this connection is highly instructive as to the value of grafting cacao.‡

The work of cacao-planting is in many countries carried out under a system of contract, and this method has hitherto been largely followed in the West Indies. It may be described as follows: The peasant enters into a contract to plant the land with cacao-trees, and receives for his

* The " scion " is the part taken from selected tree which is to form a duplicate of original.

† The " stock " is the rooted plant, to which the rootless scion is finally united and becomes one tree.

‡ *Agricultural News*, vol. vii. 1908, p. 85.

labour the use of the land for the purpose of growing annual crops of provisions, *plus* a fixed price per tree, to be paid him at the end of five or six years, when the cacao-trees begin to bear, and the land becomes useless for gardening purposes. For many years this system has been generally adopted in the island of Trinidad, and it is still in vogue. In 1889 an Ordinance or Law was passed controlling such contracts, each contract having to be signed before the magistrate of the district. The sum to be paid per tree varies in accordance with the situation and the supply of labour, but generally ranges from 15 cents to 25 cents per tree, or a little more.

Although this system is " cheapest and easiest " it cannot be held that it is by any means satisfactory; and it is better for the planter if circumstances permit, to establish an estate under his own immediate guidance. The cacao-planter would be well advised, however, in his own interest, to set about such work in a similar manner to that adopted by fruit farmers in planting their orchards; as he must use methods identical with those adopted by the fruit cultivator if he wishes to become the possessor of a first-class estate. He must plant carefully on scientific lines, and plant nothing else but selected trees, which will give him high-class produce.

By the contract system the character of a crop cannot be otherwise than very much mixed, and must, therefore, be of less value than crops obtained from selected trees producing high-class cacao.

One of the greatest disadvantages of planting by the contract system, is the possibility of having no great care exercised in selecting the seed for producing plants. The peasant's interest is to get the trees to grow, and he knows well that the inferior varieties are hardier than those which produce the finest cacao; consequently there is great temptation for him to use the seed of inferior varieties for planting. This may be obviated by the planter supplying the seed or the plants, but even then it is not always possible or convenient to supervise properly the planting

FIG. 16. THEOBROMA PENTAGONA GRAFTED ON ORDINARY CACAO

This tree was 2½ years old at the time when the photograph, for the loan of which the author is indebted to Dr. Francis Watts, C.M.G., was taken for the Imperial Department of Agriculture.

operations, so that the chances are that after all, inferior varieties will be planted. On the other hand, a proprietor cannot possibly plant as cheaply as a contractor, as the latter is better able to dispose of the ground provisions in the local market, and thus pay himself for his labour. With a dishonest contractor a proprietor often loses one or two seasons, as it is frequently found that men will take land, grow one or two catch crops, and instead of planting cacao, disappear! As contractors are for the most part drawn from the labouring classes, the proprietor has no remedy, for in the attempt to recover, he is simply sustaining further loss, as he proceeds against "men of straw." It is, therefore, clear that although the contract system is largely in use for reasons of economy, as under it there is less expenditure of capital in the earlier stages, it is infinitely better that the planter should undertake the work himself, if he can possibly do so.

The method of working, even when taken up by the planter himself, is very unsatisfactory, except in a few cases, where there is a real endeavour to adopt other lines than the old methods of peasant cultivation. There are important awakenings in this respect, and West Indian planters are now doing their best to follow out the lines laid down by scientific agriculturists, and many and marked improvements in cultivation are fairly assured.

It has been noted in previous pages that the crops of commercial cacao generally consist of a heterogeneous mixture of cross-bred varieties of the *Theobroma cacao* of Linnæus. That certain types preponderate in various countries and districts of country there is ample evidence, and that these types, when collected in bulk, form the characteristic samples of the several cacao-growing countries, is well apparent. Now the scientific method of cultivating cacao will include the selection of seed from the best types obtainable when growing seedlings, and the selection of scions from the best marked trees when growing grafted material; the latter being the only possible method whereby regular quality of high-class produce can

be obtained. The variation so clearly apparent in reproduction from seed, on any estate, must also follow to a certain degree even where close selection is made, but it is certain that better results will follow from carefully selected seed, than by the use of seed taken by the outside appearance of the pods only, or from the general crop of a plantation.

It is probable that the present method of cultivation from seed will not be dispensed with for some years to come, but there is little doubt that the sooner it can be entirely abandoned, the better it will be for the cacao planter in general, and especially for him who is wise enough to lay down an estate comprising sets of selected grafted kinds.

It is scientifically certain that the quickest method of raising improved varieties is to plant successive fields with seeds selected from approved kinds, but, as each improvement found has to begin with a single tree, and as for one first-class variety raised thousands of inferior ones will have to be discarded, it is clear that classed and named produce of regular quality can only be obtained by means of vegetative reproduction, in this case budding and grafting being the most suitable method. For the cultivation of grafted kinds the planter cannot do better than to examine closely, approve, and mark down a selection of his best trees, each to be named or numbered, and carefully labelled with indestructible labels. From these he will be able to get at least one dozen grafts each in the second or third year.

Planted out as soon as united, these young plants, if trained for the purpose, will afford grafted plants by the hundred in a year or two, and once in field rows there would be no limit to the propagation of any special kind desired; and several thousands per annum could readily be obtained from the trees without interference in any serious way with their production of fruit, as it is only the ends of small branches which are used as scions. This may appear to the cacao planter a large number, but in American and European fruit-tree nurseries 50,000 plants

of a single selected kind have easily been raised. Why not the same number of cacao plants? The apple planter pays from 50 cents to one dollar for good grafted fruit-trees, but the cacao planter asks for his at 3 cents per plant, or less even, at the present day.

If the adoption of the grafting process is desired inquiries will at once arise as to the amount of skilled labour available. In Trinidad there is ample obtainable at reasonable rates, and this is the case in other West Indian colonies also, thanks to the training undertaken by botanical establishments in recent years.

It will be seen, therefore, that there are practically three methods which are used in cacao-planting; first, planting from seed by the contract system; secondly, proprietary planting by "day labour"; and third, planting of estates with selected grafted plants taken from the finest strains, which may be taken as the highest class of cultivation which can at present be adopted.

The actual work on the three methods as regards treatment of the trees and land remains the same, but the selection and separation into various strains is work which can only succeed when carried out in a very careful manner, at first under the guidance of an expert.

The third method may be deemed expensive, but the small expense necessary to raise and cultivate selected trees will not be enough to deter the enterprising and careful planter, as he will note that by its use he will obtain strains of cacao which will carry higher and more regular prices than those obtained under the old system of cultivation, and that once his marks are known there will arise a demand for them which will show eventually a "marked" difference on the right side of his ledger.

Cacao plants in their younger stages are certainly benefited by intermediate cultivation between the rows of trees, provided the cultivator does not go near enough to injure the roots of the cacao. Planters who reside upon their estates—as all should do who are earnest in seeking for success—should endeavour to plant "catch crops" of

a kind which are readily saleable, and of a character least exhausting to the land.

There have been many proposals of late years for planting leguminous plants among cacao, with the view of affording nitrogen to the soil, but as the question will be dealt with under the head of manuring, it is only mentioned here.

The first method of planting described is that in most common use, and excellent returns have been made by estates planted under the system. The second is a slight improvement on the first, and the third or that of planting of selected strains is clearly the system which allows of the greatest progress, and promises better results than either of the others, as it is an improvement on both, both in yield and in quality.

A form of planting at stake may be effected by planting at once a Moko, or Gros Michel,* at the exact distance apart the cacao is intended to be, and sowing in or near the banana stool the three seeds; the banana stool will, with the intermediate shade crops, give quite sufficient protection to the young seedling, and the costly process of staking with "pickets" is avoided, but the lines are seldom so straight when planting this way as they are when staked with "pickets" in the first instance.

After planting is complete, the necessary field-work will consist in "weeding," "cutlassing," or cleaning between the young cacao or shade plants, and in giving individual attention to each cacao-tree and its attendant shade both temporary and permanent. Weeding and cutlassing should be done as soon as seen to be required, especially at starting; for it is evidently false economy to spend money in planting and then allow plants to be killed out with weeds for want of attention. It is also important to begin work soon enough; or before the gangs can get through, the plants may be so much overgrown as to cause damage.

The after-cultivation, *i.e.* weeding or cutlassing of a cacao estate after the trees are in bearing is a work which

* Varieties of bananas or plantains.

is done on the average about twice in each year. It is done by task work as a rule in Trinidad, and at the rate of 40 cents to 50 cents per task, or at a cost of about 5*s*. per acre. The cost of weeding, of course, depends upon the amount of weeds to be cut, and the better the plantation covers the ground, the smaller number of weeds there will be. The planter does not use the hoe freely for cutting up weeds, but it is a convenient tool for use in the younger stages of a plantation, before the roots of the cacao have taken possession of the surface. Hoe weeding is then much more effective than cutlassing, but great care should be exercised to prevent the surface roots being injured.

Whatever system is used, the bush or weeds should never be allowed to be rolled up so as to cover the stem of the tree, but should be neatly made into windrows to be distributed over the ground again, when sufficiently decayed, or used as a mulching around the base of the young trees, covering the ground as fully as possible for the purpose of preventing the rapid appearance of further crops of weeds, keeping the ground moist, and affording, by the gradual decomposition of material, a supply of suitable plant food to the young cacao-tree.

CHAPTER VI

SHADING CACAO

The question of shade for cacao is one on which there exists a great diversity of opinion among the best informed, but it is one of the very highest importance. In discussing the question, it may be mentioned that the writer, in the first years of his experience, was a non-shader, but is now a full believer in the necessity for sufficient shade, distinguishing that from too little, or too much, both of which are bad. In some few places, Grenada, for instance, cacao is most generally grown without shade. In Trinidad shade has been the rule since the " long ago," and to-day it is but few who would risk planting without it. More than usual interest, however, has been recently taken in the matter in Trinidad and elsewhere by public discussion, which does not appear to have altered much the procedure of to-day. It was argued that because coffee was found to bear better without shade in the hills of Porto Rico, *per se,* cacao in Trinidad required no shade. The author of the present work considers the logic of the argument unsound, because the premise is false, as it is a well-known fact that coffee thrives better in the hills without shade, while it requires shade on the plains, as proved by a five years' trial in Jamaica (*see* Annual Reports, Botanical Department of that island). Again, it has been argued that because a cacao leaf is green it must require plenty of sun. This, again, is illogical, as numerous green plants are known which require shade in order to thrive, and will not grow if exposed to direct sunlight. A fine illustration is before the author as he writes. In a large open pasture are fine, spreading " Saman " trees. Under these trees are

numerous plants of *Solanum stramonifolium Jacq.* (*Acanthophora Don*), producing flowers and seed in plenty. Under the shade they flourish ; in the open pasture they never become anything but stunted and abortive, and finally die out.

It is perhaps unprofitable to discuss the matter with those having preconceived ideas either way ; but in a work on cacao it is necessary in order to inform the novice of the conclusions arrived at by the experienced. On entering a new country the stranger meets with many new problems, situations, propositions, and troubles, with which he has never before contended, and in general he will find it sound advice to " stick to the bridge which carries you safely over "—the bridge in this instance being well-arranged and well-tried " shade," and not an untried plank which may fail to support its burden in the time of trial.

The island of Trinidad, which is situated immediately north of the tenth parallel of N. latitude, with a climate strictly tropical, but tempered by the prevailing north-east trade winds during the greater part of the year, produces cacao of a very fine class. Here the prevailing practice is to give the trees permanent umbrageous shade at regular intervals throughout the fields, using for the greater part trees of *Erythrina umbrosa* and *Erythrina velutina*, the first known as the " Anauca " or hill shade, and the second " Bocaré," or shade of the plains, and both known as " mortel " (*see* De Verteuil, p. 245) or " immortelle," the former being the older name, and the latter a more recent and very unsuitable one, as there is nothing whatever of an immortal character about the tree, but rather the reverse.

The " Anauca " is used on the hills, because it affords lighter shade, and the " Bocaré " on the plains as it affords a denser covering.

It is necessary for the planter to decide by observation, the actual amount of shade required by his estate, for it is clear that where the land is hilly much of it is shaded morning and evening by the hills themselves, as in Grenada,

and does not require the same amount of protection as on the level plains, where the sun strikes it from " morn till dewy eve." Instances have often been quoted where shade has been removed with excellent effect. Quite so, but in such a case it should never have been planted. Again, trees on the roadside are often quoted, and the same illogical argument is recognised. A tree may be on the roadside exposed to the full sun at mid-day, and yet shaded mornings and evenings. The morning sun has the greater drying effect, as the drying takes place earlier in the day, and the tree remains drier for a greater number of hours than those exposed to a western sun, for obvious reasons. While there can be no doubt whatever that in many places cacao is shaded more than is actually necessary, it can also be shown that in others the shading is insufficient; and the latter state occurs more frequently than the former.

It has been said that a densely shaded estate is more subject to the attack of fungus diseases than one more exposed. This, of course, is fully evident; but, on the other hand, unshaded lands are more liable to the attack of insects, such as " thrip," " red spider," " black blight," &c., than those which are sufficiently shaded.

The removal of shade, once grown, and the planting of additional shade are both difficult proceedings, the former especially so, as there is not only the danger from falling trees, but the danger of exposing the plants too suddenly to the sun, which has been found to be a proceeding likely to cause the destruction of many cacao-trees or to affect their bearing for several years. The writer has seen in Trinidad large sections of an estate almost entirely destroyed by the sun, owing to the removal of shade, and wind screens.

Cacao estates can be more quickly brought into bearing by the use of shade than without it, even the supporters of " non-shade " admitting that shade is a necessity in their younger stages. The estate also can be much more cheaply maintained if correctly shaded, as the weedy undergrowth

of an unshaded land does not appear. The author has seen the cacao-tree of commerce in its habitat. It was there found to be not a forest tree, or a tree of the open glades, but one always to be found growing best where sufficiently protected, either by the conformation of the ground or by an umbrageous covering. In Ecuador, Baron Eggers, a well-known Danish botanist, reports that the maintenance of the tree in the forest largely depends on the seed scattered by monkeys, and that trees which appear in the open are stunted, as is our *solanum*, previously referred to.

Before the evidence in favour of shade can be controverted, it is necessary for the supporters of " non-shade " to negative the reasons which have induced numbers of intelligent men in all cacao-growing countries for decades and generations to retain the practice of growing cacao under shade. The present generation can hardly claim all the common sense in dealing with the matter ; and there must be a sufficient reason, seeing that it has been continuously adopted, almost universally, by workers of the long ago, who must be credited with some judgment, some discretion and some common sense.

New theories come as innovations, and the present generation has a right to demand clear evidence of their value before accepting them ; in fact, the *onus* of proof lies with the innovator, but as yet sufficient evidence has not been brought forward to bring converts in any number to the " non-shaders' " side of the controversy, and, consequently, shading remains the standing practice in the general cultivation of cacao.

In Nicaragua permanent shade is generally planted some two years before the cacao is put in, and hedges of seedling mango-trees, kept well-trimmed, are used as wind-breaks on the boundaries or divisions of the fields. Shade trees, " madera " (*Gliricidia maculata*), are planted in the same lines as the cacao, while in some countries (as in Trinidad) the shade trees are planted between the rows of cacao. The former practice is, to the writer, by far the most

workmanlike, and has a better appearance than the West Indian method.

The distance between the rows of cacao in Nicaragua is some 15 ft., and the distance between plants in the rows some 7 ft., the shade trees coming at 30 ft. to 35 ft. apart in the same lines, but not in every line. The madera, it may be mentioned, is a smaller tree than the "mortel" of the West Indies.

In Grenada, the major part of the cacao district consists of hilly land, where the trees are naturally shaded by the ground itself for many hours of the day, making it unnecessary to use more than a minimum of artificial shade.

On the plains of Trinidad, however, heavier shade is essential, as the general use of it fairly proves, and strong additional evidence of its necessity is afforded by the refusal of the cacao to thrive when insufficiently shaded.

The "mortels" or *Erythrinas,* belong to the *Leguminosae,* and develop abundance of the nitrogen nodules common to the order. The "mortel" is known in Trinidad and Spanish America as the Madre-de-Cacao, or Mother of Cacao, the impression being that it supplied sustenance to the cacao plant, which is proved to be a truth, although now understood in a different manner to that afforded by tradition. It is stated in a paper placed before the Agricultural Society of Trinidad that "mortel" flowers add a considerable proportion of nitrogen to the soil. This point will be discussed in a later chapter.

Other leguminous plants are also capable of storing nitrogen in the soil, and making it available for plants, and hence where the recognised "mortel" does not thrive, others of the same order (*Leguminosae*) may be used, such as the "saman" (*Pithecolobium saman*), the "madera" (*Gliricidia maculata*), &c. &c. The latter takes premier place on Nicaraguan estates to the exclusion of all others in the same way as the "mortel" does in Trinidad and other West Indian islands. It is a useful, small hardwood, suitable for fuel or furniture, while the "mortel" is a soft wood, whose branches are liable to fall, and whose

wood is soft and of no value for fuel or timber. The "saman," in the author's view, is a better all-round tree for shade than the "mortel," and affords a valuable, handsome, dark-grained wood, which is worked up into high-class furniture. In Nicaragua cross-sections of the trunks are in universal use as wheels for ox-carts, the tree growing to 6 or 8 ft. in diameter.

Still, it is almost treason to suggest anything else for cacao shade in Trinidad than the "mortel," to planters who have used it for generations; and if they wish to stick to the "old bridge" of a previous page, why they will come to little harm in doing so, although they might come to less if they used the "saman."

That better trees than the soft-wooded "mortel" can be found is not to be doubted; they have not yet been found however, but if found and used, the value of an estate shaded with such trees must necessarily be increased.

To the present, however, the "mortels" still retain their place as premier shade in Trinidad, and the "madera" in Nicaragua. Many trees which have been suggested from time to time as alternatives for shade purposes have, like the "mortel," no economic value; and others of economic value have been tried, but their position at present is not a certain one.

The Central American rubber-tree, *Castilloa elastica*, has been suggested as a shade for cacao, but reports from estates where it has been tried on a large scale do not inspire confidence in its value for this purpose. The Para rubber-tree has also been recommended for the purpose. Personally the writer is not able to commend its use.

Having decided what permanent shade to use, the cultivator should decide upon his distances, &c., and plant it before, or at the time, he plants his cacao—before if possible. The usual distances are 35 ft. to 40 ft. apart each way for the "bocaré"; 40 ft. to 45 ft. apart for the "Anauca," and as much as 50 ft. to 60 ft. or more for the "saman." Primary shade, or that used for covering in and rearing the young plants, should be amply supplied.

For the smaller shade plants, corn (*Zea mays*), pigeon or gongo pea (*Cajanus indicus*), tannias, eddoes, or cocoes (*Colocasia esculenta* or *Xanthosoma belophyllum*), castor-oil (*Ricinus communis*), cassava (*Manihot utilissima*) and the banana or plantain (*Musa sapientum*) can be used. The banana or plantain used for shade is usually planted between the permanent rows of cacao. If cacao is at 15 ft., then banana 7½ ft., and so on. A variety of plantain commonly known as the "moko," or "jumbi plantain," is preferred to other members of the family by Trinidad planters for the purpose of affording secondary shade. The fruit of this plant is, however, considered fit for little else than cattle food, though the green fruit when dried and pounded makes a wholesome, pleasant, and nutritive meal, which is a most suitable food for invalids and children. Since the banana trade has assumed such large proportions in the West Indies, attention has been called to the value of the banana as a shade plant for cacao. The fruit shipped from Jamaica to the United States is known as the "Martinique banana"; but in the various colonies it appears under different names, and in Trinidad it is recognised only under the name "Gros Michel." This plant proves to be very suitable for shade purposes in the intermediate stages. The distance at which intermediate or temporary shade plants should be placed apart is merely a matter of convenience. The skilful will always take care he has enough, and not too much, but as they are all ultimately removed, the exact distance they are placed apart matters little really so long as the cacao gets the necessary shade in its youthful stages. The "moko" is, however, not so much used as formerly, on account of its being badly affected by the prevailing banana disease, *Marasmius semi-ustus*. Evidence with regard to value of shade has recently come to the knowledge of the author. A paper on cacao cultivation was read before the Scientific Association of Trinidad in the year 1865 by a Mr. Law, who was about to establish large cacao estates in the island, a copy of which is in the writer's possession. This gentleman propounded the

theory that cacao-trees required no shade "after their third year." He followed his own convictions, and allowed no shade. He expended large sums of money, and estimated that his estate of two hundred acres would be worth some 47,705 dollars at the end of seven years. His estates failed and were sold, and they are now owned by men who believed in, and who planted shade, and under it are yielding good crops. This appears to be sufficient evidence of the value of suitable shade for cacao-trees. It is, however, reported that official experiments under Government control are to be made in Trinidad in order that the matter may finally be threshed out; the result of such experiments, it is confidently anticipated by the writer, will be a decision in favour of a continuance of the present general practice.

CHAPTER VII

MANURING

In no part of the practice of the cacao planter is there more divergence of opinion than in the methods most suitable for applying manure, and the kind of manure which it is best to apply. This arises largely from a want of proper knowledge of the requirements of different soils and of the tree itself. To understand properly when a tree requires manure and when it does not, some standard or guide is required as to what a cacao-tree in good health and thriving condition really should be like. There should be an ideal or standard of culture, and this should be the guide in all important operations. Let us premise, therefore, that a tree in good health needs no manure. Such a tree is doing its work well, and to the fullest extent, and therefore to feed it with manure would be like over-feeding a horse, and it would just as quickly get "out of condition." To make the point clear, the writer will describe what his ideal is of a tree in good health. It is a tree which from its seedling stages has annually made good periodic growth, producing leaves and branches strong and without disease or blight, one which produces an average crop of fruit without dropping it prematurely, or losing it by attack of parasitic diseases; a tree which can withstand a maximum of either rainfall or drought, without its general bearing being affected. If it does this, it is certain evidence that plant-food is present in sufficient quantity, and such a tree needs no manure, for manure is but food, and so long as it has a sufficient natural supply to maintain it in good health it needs no artificial substitute, and will do its work best without it, and to give such a supply

would probably reduce crops instead of increasing them. It must not, however, be understood that no manure should ever be applied to cacao, for that would be in direct opposition to the principles and practice of agricultural science, and could not be upheld, for when trees show by their state of health that their natural food-supply is exhausted, other supplies must assuredly be furnished.

The application of suitable manure to trees planted in poor soil, to trees in weak health, and to trees which it is desired should make a more than usual rapid growth to serve some purpose of the cultivator, has the best effect; but the application of strong manures to trees in good health and in average bearing would tend to encourage rank and sappy growth which would be non-productive, and loss of crop would result. A tree, like a horse, can do more work when in "condition" and with less exertion than it can if overfed and surfeited.

Manure may with advantage be applied to a tree should it be found that the plant has set itself more work to do than it can efficiently carry out, *i.e.* by setting a larger crop of fruit than usual. In such a case the application would certainly be beneficial, and enable the tree to carry a crop which, under ordinary circumstances and without manure, it would not be able to; but the application of manure to a tree before the fruit is formed, or at any early period of its growth, would probably result in inciting the tree to produce a large amount of branch growth to the detriment of the fruit, which would probably fall. No one has yet been able by mere inspection to decide what class or kind of manure should be applied, or the quantity to apply to obtain best results, and this must therefore be ascertained by experiment, assisted by analysis, but cannot be determined by analysis of the soil alone. It will be found quite impracticable to follow blindly the advice of the "nitrate salesman," the "animal manure drummer," the agent of a phosphate company, or of the potash merchant, as before purchasing, it should first be

ascertained what the land requires before plant-food of any kind is used for the enrichment of the soil. The same argument applies to the use of material now largely advertised as being able to supply nitrifying organisms to the soil by aid of certain artificial cultures of bacteria. If bacteria are already there in sufficient quantity none need be added; but if they are not there steps should be taken to place them there by means of artificial inoculations, or, better, by the application of manure which contains or will generate them in due course in a natural manner. It is a difficult task, however, to find out whether they are in the soil or whether absent; and here again experiments must be relied on for information. Having found what manure is required, it should be applied judiciously, *i.e.* neither under or overdone, and, if nitrifying organisms are absent, means should be taken to supply them.

It will be seen, therefore, that the application of manure requires judgment and skill, and should only be carried out under the personal supervision of an experienced cultivator, or loss may result. Where, however, a plantation will evidently be the better for the general application of manure on account of the soil proving to be naturally poor, regular applications should annually be made in the best form available.

Any kind of chemical manure, nitrogen, potash, or phosphate, &c., should be applied with the greatest caution, and buyers should know by means of chemical analysis the exact proportion of ingredients it contains, in order to be able to supply it in a systematic manner. Farmyard or stable manure can always be applied with much greater safety than chemical manure, but its action is not so quickly apparent, though its effects are generally more permanent and it has a mechanical effect upon the soil, not obtainable from artificial manures, which is highly beneficial to growing plants. In a lecture by Dr. J. A. Voelcker, M.A., F.I.C., &c., the following statements occur which are of the greatest importance to cultivators in general. He says: "I have not unfrequently been asked

to say from analysis of the ash of a plant what proper manuring should be. This is, as I have pointed out, a question not to be answered from an examination of the ash alone, but has to be taken in conjunction with the soil on which a plant is grown and the power which that plant has of attracting various soil ingredients, in short, it has to be the work of experimental inquiry."

Dr. Voelcker sums up his lecture with further pointed remarks of the highest importance to the cultivator, in the presence of the fact that it is popularly supposed that the chemist is able to decide by analysis alone many points which it is absolutely necessary should be decided, which can only be decided by cultivation experiments; and *it is only when theories are proved by actual experiment in the field that the doctrines of the laboratory should be adopted for general use.* He says: "While I have in the foregoing put out some points in which a knowledge of chemistry may be useful for the better understanding of the processes which go on in plant life and growth, and for the application or practice of the principles which have been laid down, it is only right that I should indicate some of the limitations which have to be put, in short, to name some of the things which chemistry cannot do. First among these I would admit that chemistry has yet failed to give any explanation as to why one plant likes this or that particular ingredient, or rejects one or the other. What the particular ingredients do in plant structure, or how their absence would be felt, remains a matter of further inquiry. So that there has not yet been given any adequate explanation as to why one plant will grow on a particular soil and not on a different one, why potatoes, for example, will grow well in a sandy loam, and not in a heavy clay, while fruit-trees and hops need a fairly heavy soil. Again, chemistry has not solved the question of how to produce quality and flavour without sacrifice of quantity. In what, indeed, quality and flavour consist is itself a mystery."

The application of manure is a subject upon which chemists and vegetable physiologists differ in many respects. The chemist is apt to insist upon the manure being buried beneath the soil, or he says much of its value will be lost owing to the dispersion of its volatile properties by moving air, but the cultivator may easily ascertain the best method of applying manures of all kinds, if he studies the life history and character of the plant and the nature and morphology of its organs of assimilation, and moreover, the frequent showers of the tropics prevent any great waste of the volatile constituents, unless they come so heavy as to wash them away. To dig deeply about the roots of a surface-feeding plant for the purpose of applying manure would be absolutely absurd, as we should thereby destroy the very organs or mouths, which are needed to take up the plant-food presented to them, and are situated in the proper place to carry out the process to the best advantage. Practices of this kind are often recommended by new-comers to the tropics who have only been trained in the agriculture of a temperate climate. The writer has seen the practice carried out with dire effect more than once in Trinidad, and it is quite certain, that although it may be carried out with considerable safety in a temperate climate, when trees are at rest, it is fraught with the greatest danger in the tropics.

The destruction of roots which the operation of burying manure occasions, would, in most instances, completely nullify the action of the manure applied, as the broken roots would not have the power, or the same amount of surface for absorbing food, as when uninjured; and the manure applied, through its coming into direct contact with injured tissue, would tend to destroy the roots by its caustic character, rather than be absorbed by them. That beneficial results follow the application of manure when buried beneath the surface, is of course patent to the novice, but in the case of surface-feeding plants, it is only after the roots have recovered from the injuries done by the digging, that they are able to take up any manure

which has been applied when these organs are again in a condition to perform their proper functions. Even granting that no special harm is done to the trees, there is inevitable delay in the economy of growth, the hazard of losing a flowering season, and consequent loss of crop.

With deep rooting plants the burial of manure is the most economical method of application, as there can then be no loss of volatile constituents.

If we think over for a while the course which nature has pursued for ages in supplying plants with their food we shall find that the method adopted is purely surface manuring, and this method with not a few modifications is generally being adopted in what is called "Orchard Culture." Even the ground the plant grows on has been almost entirely formed, by additions to its surface, by detritus from surrounding lands, by deposits made by flood waters, or by decay induced by the flow of water over its surface carrying with it solvents which are able to disintegrate the materials of which it is composed. For tree cultivation, surface manuring is the only method in which the manure can be fully utilised, and we can easily take steps to guard against evaporation or dispersion of volatile principles, by covering the manure with material which will act as an absorbent and thus retain the constituents likely to escape.

In practice, the covering of the ground with fresh or decaying vegetable material is known as "mulching," and it has been proved that for cacao the practice is of the greatest value.

Dr. Francis Watts, C.M.G., Imperial Commissioner of Agriculture for the West Indies, in reporting on experiments carried out in Dominica, has the following with reference to five experiment plots of cacao: "The most interesting plot is the one mulched with grass and leaves, the sweepings of the lawn at the Botanic station. In the first period this plot, though giving greater yield than the no-manure plot, fell far behind the plot receiving dried blood, or the plot receiving complete manure, viz., dried blood, phosphate

and potash (2A), and that receiving dried blood with phosphate and potash (4E). The yield was practically identical with that from the plot receiving dried blood alone (3B). In the third year this plot far surpassed all the others, giving yields 66 per cent. greater than that obtained from the no-manure plot."

In the Botanical Department, Trinidad, for many past years mulching has been taught as a valuable method for orchard culture of cacao and other products, and in Vol. v., Botanical Bulletin, Trinidad, 1902–3, the following beneficial effects are recorded, viz., that mulching:

(1) Keeps down weeds.

(2) Prevents evaporation, and keeps ground moist.

(3) Furnishes suitable manure in gradual supplies.

(4) Attracts earth-worms to the surface, and causes them to cut numerous burrows, which aerate and cultivate the soil; in fact the worms actually manure it by carrying down into the tunnels the decomposed organic matter.

By the use of "mulching" it is certain that cacao can be grown successfully on lands which could not produce it otherwise; and on some of the large estates the practice is being adopted, especially on those fields which suffer during the dry season.

In the preparation of land for general crops of an annual or perennial character, such as European cereals, the thorough incorporation of the manure with soil is, of course, carried out as completely as possible; but with this kind of manuring, in connection with cacao cultivation, we have nothing to do, as it is not required, and can only be employed where a field is clear of growing crops.

On this point, the tropical cultivator who reads advice intended for a temperate climate, is very liable to err. His cultivation is orchard cultivation and the crop is always on the ground; which is quite different from the cultivation of cereals, where the ground is clear for manipulation once a year. It will be seen, therefore, that the course of manuring recommended for adoption is one which is based upon careful observation of nature's process of

surface manuring. We cannot command nature, but can venture to assist her, and we can best do so by following out and understanding to the full the methods she employs.

The cacao-tree, although it likes a deep rich soil, is also a surface-feeding plant, and the ground around the trees cannot be dug or forked with impunity, for, although the tree will stand considerable hardship, it is nevertheless materially injured when the roots are mutilated. There are conditions, however, such as when the surface soil has been thoroughly baked by drought, when it would be beneficial to prick it up lightly with a fork, taking care not to break the roots (vertical forking). A slight forking is, however, permissible at times, previous to applying farm-yard manure upon the surface, having due regard, of course, to what has been said in the foregoing remarks on the injury caused by the injudicious use of fork and spade. Manure applied to the surface should be covered if possible with a thin layer of earth, but if applied in the form of compost this is not so necessary an operation, as the volatile constituents of the manure are then in a great measure held fast. The clearing and shaping of the drains will, as a rule, provide enough suitable material for covering in dressings of manure.

In applying chemical manures of a caustic character, it is always well to mix them with a suitable proportion of absorbent earth, and to cover again with a coating of the same material.* The primary object in applying manure is to maintain a due proportion of plant-food when land has become exhausted of its natural constituents, or to supply something in which the land is deficient. It is of course patent that with the continued production of annual crops a large quantity of material is removed from the soil, and this must be replaced either by nature or artificially, or the crop will fall short. Farmyard manure takes a foremost position for this purpose amongst all others, and long-continued practice shows that when

* A very interesting lesson may be taught by the application of small quantities of ammonia sulphate to living roots and noting result,

properly applied it is of the greatest value to the land, not only for its manurial properties, but also for its mechanical action upon the soil, and moreover, it can never be as dangerous to use as chemical manures, which are admitted to be decidedly hazardous when applied by unskilled labour. By unskilled labour the writer does not mean the peasant or farm hand only, but educated people who take up the business of agriculture without due study, acting under the impression that they were "born to till the ground."

In some cases quicklime becomes a powerful ally to the cultivator, but, on the other hand, its undue application tends to exhaust the soil of valuable constituents by setting them free much more rapidly than is required, and therefore it should always be used with great caution. In nature, manure is given to the roots of trees by the decomposition of vegetable and mineral substances, and is carried downwards by rain-water, worms, and other agencies. Rain-water itself also provides a certain quantity of plant-food in solution. The plant or tree does not, however, obtain all its food from the soil, as the surrounding air provides it with a large portion, which is taken up in gaseous form by the leaves. It should therefore be the aim of the cultivator to maintain on his trees as large a proportion of healthy leaves as they can carry. Whether the food is taken up by the roots or by the leaves, it is in the latter organs that all the material necessary for the purpose of growth and reproduction is formed and distributed. The leaves are in fact the laboratory of the plant, in which all the most important changes of the vegetable fluids are carried out.

The importance of maintaining at all times a healthy crop of leaves cannot be over-estimated; and for this reason a system of pruning should be adopted by which they are made to distribute themselves with great regularity over the branches of the tree, so as to place them in a position to carry out the work they are called upon to perform.

Calculations have been made showing the large amount of phosphates annually carried away by the cacao crop, and deductions from these figures have been drawn to show that the necessary supply must in the end run short, and that the lands will become barren unless it is artificially supplied.

Such conclusions are probably based upon an insufficient knowledge of the conditions actually existing, for it is a fact that there are now estates which have been continuously cropped for fifty years or more, without any apparent diminution in the production of the trees. It has, therefore, been shown that the phosphates are either in the land, or are supplied to the land in some way not as yet generally recognised—such as an incidental increment of plant-food furnished by agencies coincident with animal and plant life. The annual loss of phosphates when stated in tons appears to be large, but when the annual loss per tree is shown as being somewhat over three drachms, it does not then appear so formidable a proposition, as it could clearly be supplied by the existing animal life. If, however, crops can be increased by the application of phosphates, it would tend to show a further want of this constituent; but if the crop is not increased it would be strong evidence that sufficient is at hand, a point which can easily be proved by a suitable course of field experiments.

Well-made farmyard manure is, however, well adapted for the cacao estate, especially if sufficient animals can be kept to maintain a constant supply.

Cacao-planting and stock-farming are industries which can be profitably run side by side, as the manure from the latter—now practically wasted in many colonies—could be utilised for increasing the output of cacao to an extent not as yet fully realised.

There can be no doubt whatever that the natural incidental increment of plant-food is very high in the western tropics, and must be considered on quite a different basis to the conditions existing in temperate climates.

The " mortel " or shade tree, *Madre de cacao*, or *Erythrina*, of several species, is known to produce flowers showing a high nitrogen content. Analyses of flowers of these trees, published locally in 1901 and 1902, showed a difference of 40 per cent. in the nitrogen content. In the latter year the ascertained percentage of ten samples was 3·35 per cent., while in 1901 the report showed a return 40 per cent. higher.

Flowers of the English elm have been found to contain 3·54 per cent. of nitrogen, while the flowers of *Gliricidia*, the tree used as shade in Nicaragua, gave 3·30 per cent. of nitrogen.

As regards manuring in general, it is necessary for the cacao planter to ascertain for himself the kind or class of manure he can use with greatest success on the various portions of his estate. It by no means follows that a manure suited for one portion of a plantation would be suitable for another field; nor can the manures used successfully by a neighbour be relied on as suitable for other fields until proved so by actual trial and experiment of sufficient duration, and the chemist has to prove by experiment as well as the planter. The method of application of manure is another question to be considered. Sometimes manure is best applied in small quantities at intervals, at other times it may be applied in larger quantities with better effect. Some manures may be mixed with others, and some may on no account be mixed. In mixing manures before applying them to the land, chemical changes can take place, so that a valuable ingredient may be lost by a part of it flying off as gas, as for example the mixing of lime with such as actually contain nitrogen, stable manure, guano, or ammonium sulphate, &c., when the most valuable ingredient, the nitrogen, is lost in the form of ammonia. Sometimes an easily soluble manure changes into one soluble with difficulty, and so loses in value, as for example the influence of lime on easily soluble phosphates. Secondly, mechanical changes can be caused by mixing two or more manures,

and so make their application more costly. Mixing kainit or other potash salts with other artificial manures, if not spread immediately, will give a mixture which soon becomes a hard solid mass, which must be broken up before application. To remember what manures can or cannot be mixed for any length of time, shortly, or not at all, before spreading on land, cannot be expected of any one who is not well up in the chemistry of manures. A diagram is reproduced on this page which readily and

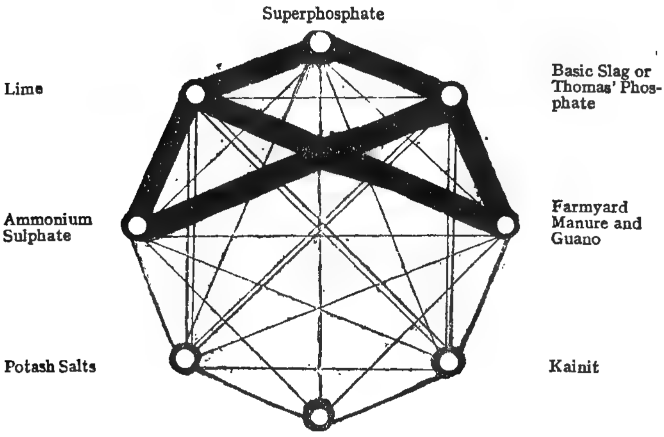

FIG. 17.—Dr. Geehen's manurial diagram.

simply shows what may or may not be mixed. It is taken from an article by Dr. Geehen in the *Australian Agriculturist,* republished by the Queensland *Agricultural Journal,* and by the author as editor of the Trinidad Bulletin, 1904–5.

Those manures joined by the thick lines must never be mixed before using. Those joined by the double line may be mixed immediately before spreading, and those by the single line can be mixed together at any time. Two other single lines might run between the base point and the right and left upper angles, but these were left out in making the " electro."

The placing of manure in proper position for speedy assimilation is an art to be practised by all aspiring to become skilful cultivators, and in order to place it properly the operator must make himself acquainted with the position of the primary organs of absorption, namely, the points of the roots and the root hairs.

These are found most numerous in the outer circle of the roots, and not with the older or non-absorbent roots which act mainly as channels for conveyance of material. It is useless to pile up manure close around the stem of a tree, as the roots there situated cannot take it up. There is nothing which kills a tree quicker than the piling up of manure or decomposing vegetable matter around the base of its stem ; many a fine tree being killed by the ignorant cultivator, where this practice is followed, as it causes the destruction of a ring of bark at the ground line. Manure should never be placed close to the stem, but immediately above those parts of the roots which can absorb and assimilate it.

In any case, even with very young trees, manure should not be placed closer than 12 in. from the stem. With older or matured cacao-trees it is best to allow a cleared circle at least 4 ft. in diameter around the base of each stem, which may be extended to 10 or 12 ft. with advantage, in the case of the largest trees. Local experiments in Trinidad, made in an open savannah, have shown to perfection the rapidity with which manure is taken up when placed on the surface, and the immediate benefit it shows in the growth of the tree. Surface manuring, properly carried out, is a true following of nature's teaching, readily practicable, highly successful, and thoroughly scientific.

CHAPTER VIII

PRUNING CACAO

Upon the number and proper development of the leaves of a tree, the whole of its power of growth and production depends. The development of leaves is therefore the primary object of the cultivator, as they are really the factory or laboratory where all the material for the production and extension of growth of stem, root, and branch is formed. There is reciprocal action between the roots, branches, and the leaves. The roots in their growth keep pace with the development of the stems and branches, and it may be taken as a general guide that there is intimate and constant relation between the horizontal extension of branches and the lateral spreading of the roots. It is not by watering a tree close to the stem or trunk that it is kept in vigour, but by applying the water on the soil at the extremities of the roots, which correspond with the diameter of the circle containing the spread of the branches, *i.e.* the spread of the roots horizontally is generally equal to the lateral spread of the branches, and the outer edge of the circle containing the roots is clearly the place where both moisture and manure can be most satisfactorily and economically supplied. By adopting a system which allows roots to spread freely and does not arrest their development, we are imitating what takes place in nature, than whom there is no greater or better teacher or guide, if we would have well-grown specimens. If we wish trees to be firmly rooted we must allow their branches to spread freely, as there is no doubt of the reciprocal action which exists between the branches and roots, as well as between the leaves and roots. The spreading of roots under

favourable circumstances is often of a remarkable character, and it appears that they possess the power of working in the exact direction in which food-supplies lie with almost unerring certainty, although it may be a situation outside their ordinary or regular circle of growth. In fact, if food-supplies are placed within reasonable bounds, it is seldom the roots of a tree will fail to find them, but it is evidently better for the conservation of the energy of the plant that such supply should be placed as near the absorbent circle as possible. When trees are uncommonly vigorous, owing to an unusually abundant supply of nutriment, it is sometimes necessary to check root growth, or root power, by pruning. A circular trench dug around a tree at suitable distance from the stem, will often throw a previously non-fruiting tree into a regular cropping condition, but this is seldom necessary, except when local conditions and surroundings are the cause of a too vigorous growth of woody material. Such a condition is often incited by the presence of too great a proportion of nitrates in the soil.

The act of pruning is popularly supposed to cause directly the production of fruit. That it has this effect, when properly carried out, there can be no question; but the effect is not so direct as is often assumed. The material for the production of fruit is laid up by the leaves, but if the leaves have not done their work properly, or are insufficient in number to accomplish it, all the pruning in the world could not bring such a tree at once into a fruiting stage. In special cases where conditions are favourable, the act of pruning is well known to join in hastening the production of fruit by directing sap into nascent flower buds.

Given a young tree in good health, and with a single stem, the pruning should be begun by the regulation of the primaries, or first branches made by the tree. That is to say, pruning should in the first instance be directed to securing a proper form and arrangement of the branches. There should, as a general rule, be only three, or at most four, primary branches left on the cacao-tree. These

should be encouraged to extend themselves laterally, as they have a natural tendency to do, and should be encouraged to develop at regular distances the secondary branches. The tertiary branches should also be encouraged to grow at regular intervals.

In the primary stages, pruning should be performed before the wood becomes sufficiently hard to require the use of knife by the method known as "pinching." This is carried out with the thumb and finger, and all succulent shoots not required, can be headed back or "stopped" by this means. At all times it should be the endeavour of the pruner to maintain the tree well balanced, *i.e.* it should not have one branch growing more rapidly than another, so as to make the tree appear lop-sided from any one point of view. Many of the older cultivators do not regard this point sufficiently in carrying out their pruning operations, and many branches are left, owing to their being bearing branches, which, for the permanent security of the tree, for its general appearance, and for its bearing qualities, should be removed. It is much better to check at once the tendency of a tree to assume an irregular and uncultivated form, than to allow a branch to grow for a time and finally be compelled to remove it when of large size.

The pruning of a cacao-tree should be conducted with a view, in the first instance, to the ultimate production of fruit. Unless we have a plentiful supply of good healthy leaves, evenly distributed over the tree so as to obtain the maximum of light and air they require, we cannot expect to secure large crops of fruit; in fact, unless the machinery is in good working order and the supply of fuel abundant, we cannot expect a good output. The leaves and roots represent the machinery, and water, sunlight, air, and plant-food acting together represent the fuel supplied.

The branches of cacao-trees should be evenly distributed, so that the leaves they carry may be maintained in good health, and just thinly enough distributed to admit sufficient sun and air to mature the fruit. What is sufficient

sun and air in different situations can only be found by long experience.

It should be a rule when pruning that too many branches should not be removed at once. It is a mistake to prune heavily at any one time, as it gives the trees too great a check, and causes too great a disturbance of the growth. The effect of heavy pruning may be seen by the increased growth of young shoots (*chupons*) which appear at or near the place where branches have been removed. These, in most cases, are quite useless and have to be removed, causing a waste of plant energy, for if properly directed, the material used up for their growth would have considerably added to the health and strength of the tree. In pruning neglected trees, the first thing to be done is to cut out useless wood, or wood which can never be expected to bear or to produce bearing branches, or wood that is diseased or cankered. The next thing is to equalise or balance the trees, and the last, to thin out the branches and foreshorten them where required.

In removing branches the greatest care should be exercised not to make jagged, ragged, splintering or slivering cuts, but to make clean and even cuts close to the wood and near to a bud or young branch into which the sap will be presently directed if the operation is well performed.

The young branches which are often found growing erect (commonly called " gormandisers " from the rapidity of their growth) are productions which show that the parent stem, as it stands, does not provide sufficient channels for the expenditure of the sap supplied by the roots, and in consequence this sap provides for itself an outlet, and expends itself upon the production of rapid growth in other directions. It shows that the channels for the conveyance of sap are clogged or contracted and that the amount of sap produced cannot pass into the more matured portion of the tree. It is also an effort of nature to recover itself from hard work. Every physiologist knows that unless branches are produced roots

cannot be, and the production of root is in exact ratio to the production of branch, as previously mentioned, and the more these are allowed to grow, the larger amount of root-power the tree will have; but the cultivator should see that this power is judiciously expended by directing growth in the required channel. When, however, a tree is bearing fairly in proportion to its size, it is better to remove these branches at once, as it is certain that by affording free opening for the expenditure of plant material they rob the crop of the full amount of nourishment it should obtain, and the productive power of the tree is seriously affected. They should be removed, however, as they appear, and not be allowed to grow to a large size and then removed, as that practice would simply be a waste of the material used up in producing them, instead of it being available for the production of fruit. It is a bad and slovenly practice to allow suckers or "gormandisers" to be pulled off. They should always be removed with a sharp knife when the wood is too hard to allow of their being "pinched" between the thumb and finger, and the cut treated with an antiseptic.

In cases where the cacao-tree has evidently become somewhat worn out or partially barren, *i.e.* where its bearing wood shows evident signs of being out of condition, it is a good plan to make use of "gormandisers" or *chupons* to assist in rejuvenating the bearing parts of the tree and give it a new lease of life. This can easily be done if the most suitable are allowed to grow, and trees can be more quickly rejuvenated by this means than by any other.

By allowing one or more of these branches to grow from suitable points and by treating it in a similar manner as we would a young plant, it is possible to renew and bring again into bearing trees which, if left to themselves, could not be expected to yield any crop. It is really wonderful in what a short time this operation can be completed if skilfully carried out.

After the tree thus treated has assumed fair proportions, the older wood should be carefully and gradually cut away,

but not all at once, as heavy prunings always seriously interfere with the growth of the tree. Heavy pruning should always be done with a saw, and the wounds should afterwards be smoothed over with a sharp knife or chisel, as they always heal better if thus treated, and, besides, they should be covered with a coating of tar and clay or other antiseptic dressing, to prevent the entrance of parasitic fungi, and the cacao beetle from laying its eggs in the wounded parts.

A mixture of coal-tar and clay, as described below, may most conveniently be applied to all wounds. Pruning with a cutlass, knife, or cacao hook should never be allowed. The instruments used should be those which are able to carry a keen edge, and the pruners should always be supplied with the means of properly sharpening their tools without leaving the field.

The time for pruning the cacao-tree is a subject of frequent discussion, on account of the influence which the moon is supposed to have upon the flow of the sap, &c. Such discussions are interminable. Some assume that the sap, like the blood of an animal, courses through the vessels of a plant periodically, and that the moon has direct influence upon the flow. Some again conclude that a tree has more sap in its branches at full moon than at other times, while others declare that insects attack the trees more at full moon than at other times. In nearly all these cases the premise is erroneous, and therefore the conclusion cannot be a correct one.

If the moon has any influence, the writer may at once confess that in all his practice he has never discovered it. He would ask those who assert that the moon has influence on the condition of a cacao-tree to prove it by something more than mere assertion, and to allow him the privilege of dissent until such proof is made known. The writer does not desire any one to accept his opinion, viz., that the moon is entirely a negligible quantity, unless he may choose to do so, but he objects entirely to be forced to accept the opposite conclusion. If it pleases certain

planters, to waste time and money (in his opinion) in waiting for certain phases of the moon before commencing to prune their trees, to gather their crop, or to sow their seed, that is their affair; but he cannot for a minute sanction or teach such a doctrine, as he believes it to be incapable of proof. The writer knows many planters, for whom he has the greatest respect, who regulate the work of their estates in some part at least, by the phases of the moon; but he cannot see that it would be right on that account to dispense with the call for scientific proof of the theory they adopt, as without this proof, the theory is to be regarded as one upon which it would not be safe to rely.

Whether the moon has any influence or not, had better for the present be left an open question, not that the writer has any personal doubt upon the matter, but still the question is one which, take it as one will, has little or no influence upon the progress of cultivation, as each individual may adhere to his own pet theory without being placed at any great disadvantage. In over forty years' practical work in the temperate zone and in the tropics, the writer has carried out hundreds of experiments bearing on the subject of the moon's influence on plant life; and yet in none of these has he found anything to support the conclusion that the moon is a controlling power over the operations of the agriculturist.

It is taken as an accepted rule that in established cacao, pruning or "trimming," as it is called in Trinidad, is best carried on at the close of "crop time." The conclusion is a reasonable one, as the trees are then devoid of both flowers and fruit, and at this period there is less possibility of injury.

On the first-class estates where cultivation is carried out in the best manner, the tree should annually receive attention in the matter of pruning, &c. Every tree should be visited and carefully examined. On many estates it is the custom to prune only at intervals of once in three or four years. Such cannot be considered good practice, as the writer has before shown that the less pruning done to a tree

at one operation the better. On young plantations pruning should be regularly attended to at monthly intervals in order to guide the tree into proper shape in its youth.

It should be remembered that a cut made in pruning a tree is just as much a wound as the cutting of a finger from the human body, and that, although the plant may repair the injury to a certain extent, still the wound remains, and unless it heals, produces a certain disorganisation of tissue, not seldom resulting in decay and death, which will probably occur at the end of a long season of drought, when the vitality of the tree has become exhausted by an unfavourable season.

The treatment of wounds in cacao was for long years utterly disregarded, until it was shown beyond doubt in the writer's previous contributions, and in various press articles, how largely this neglect affected the interests of cultivators by inducing disease and thus reducing the annual crops. In an article in the Trinidad Bulletin the method of treating wounded surfaces on living trees was fully described. This treated upon the practice of pruning; how to cut, when to cut, how much to cut, and how to sterilise the wounds after cutting. In it pruners were advised to cut large branches, at distances a foot or more from the place where the final cut is to be made, in order to prevent splitting and tearing away of bark and wood by the weight of the falling branch, and then afterwards to remove the foot-long stump by a clean cut. For dressing, tar and clay or other efficient antiseptic is recommended. Coal tar has always served the writer's purpose, his father's, and his grandfather's, as an application to wounded vegetable surfaces, made when pruning; and the fact of their ages covering over a hundred and fifty years is surely a recommendation as to its harmlessness and efficiency. Other practitioners prefer other dressings, and such may be tried if desired; but hitherto nothing so effective has been noted as coal tar applications.

Fig. 18 shows how a branch should not be removed.

In this a stump has been left without dressing. Water and fungi have effected an entrance, and the result is that the wood has rotted away, causing a hollow which will eventually cause the death of the whole tree. In Fig. 19 the cut has been made " close in," as the branch should be removed, and growth has commenced and will finally grow and cover the wound, completely excluding the outside

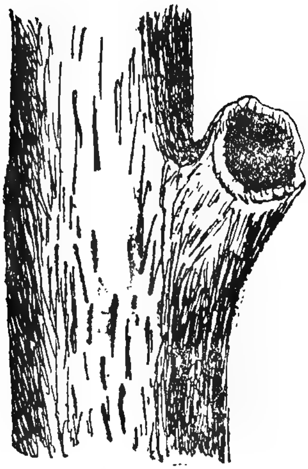

Fig. 18.—An undressed stump.

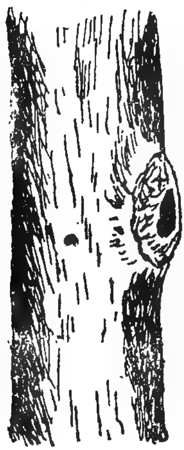

Fig. 19.—A properly treated cut.

air. A cut should always be covered with dressing, and the air excluded until it is completely healed over.

Fig. 20 shows a slab of wood where a similar branch has been cut, and where the cut end is not only healed over, but the wound has been completely covered and concealed with a large amount of wood, without the least decay being apparent. Wounds on a cacao-tree may be healed quite as effectually if correctly treated. The slab of wood from which Fig. 20 is sketched is in the possession of the author.

In the West Indies it is evident that hundreds and thousands of trees have been destroyed owing to careless

pruning, but the awakening has come, and better and more scientific treatment is being adopted; but many years must yet elapse before the marks of these careless methods of the past will finally be obliterated.

Another care in making the cut should be to see that the face of it is either perpendicular or (if possible) sloping at a sufficient angle to shed rain or water from the wound, as nothing is so favourable to the entrance of fungi as the maintenance of a constant state of humidity on or in the neighbourhood of a wounded surface.

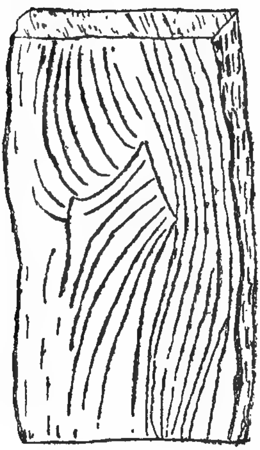

FIG. 20.
A well-healed wound.

As regards hygiene in the field, it is incumbent upon the planter to take every possible means to ensure the clearing away of all branches and other material which will harbour or allow the development of spores of destructive fungi, and to be careful in removing and burning as far as possible all prunings from the ground. If left to rot upon the plantation, these prunings become the home of innumerable wood-destroying insects and beetles which are inimical to the welfare of the cacao plant. There is nothing like tidiness and cleanliness in any cultivation, and departure therefrom is sure to produce sooner or later its concomitant evils.

The practice of pruning, the way to hold the knife or saw, cutlass or cacao-hook, cannot be taught by any writer. The inexperienced hand should seek practical instruction, and, even then, it requires a considerable amount of time and experience ere he will be able to handle his tools with dexterity and precision.

The difference between a slovenly cut and a clean cut is at once apparent when the work is compared, and no workman should be permitted to practise pruning upon

valuable trees, until he is well accomplished in the practical use of the tools employed.

The skilful pruner can, by a proper handling of his tools, and cutting back to buds situated in the positions from which he desires a branch to come, form the tree at will into the shape he requires ; and the plantations in which such skill is exhibited, will always present a tidy and cultivated appearance, while those treated by the negligent and unskilful pruner will always look untidy and irregular.

Good maxims for the cultivator are, " prune lightly, but prune often ; prune carefully, but prune with decision. Prune to allow of the development of a large amount of healthy leaf surface, and a crop will come year after year, and your trees will remain healthy and productive."

CHAPTER IX

DISEASES OF CACAO

In 1892 the author published the following on the subject of cacao disease: "Fortunately for the cultivator the serious diseases which attack the cacao are few; perhaps the most common is that known as 'canker.' This word is, however, somewhat misleading and indefinite, as there are several diseases improperly called 'canker' which are caused by entirely different organisms. Studies made during the past eighteen years by the writer and others have shown that there are many diseases to which cacao is subject that were unknown in 1892, a few of which are of serious importance. That they have been discovered recently is, however, the result of diligent search. It is highly probable that they existed in the forest long before cacao was extensively cultivated, but at present there is no proof, or even suspicion, of any one of them having been introduced."

The following extracts from De Verteuil's "Trinidad," * 1884, pp. 431–433, show that certain diseases existed long ago, although their exact nature was not well understood:

> The prosperity of the colony had now (1703) reached its culminating point, cacao selling at a very high price. But in the year 1727, according to Gumilla, not a disease of the trees exactly, but a blight attacking the pods under certain atmospheric influences, destroyed the crops. . . . Governor Nanclares had for his successor Colonel Don Pedro de la Moneda (1757). . . . It was about this time that an attempt was successfully made to reintroduce the cacao plant. A new species, the Cacao Forastero, which being hardier, although not yielding the same fine quality, succeeded beyond expectation. It is this quality which is still cultivated in our days.

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* "Trinidad: its Geography, Natural Resources, Administration, Present Condition and Prospects." By L. A. A. De Verteuil, M.D.P. Second edition. London: Cassell and Co., Ltd., 1884.

De Verteuil, it appears, considered that a previous introduction had been made, which, from the proximity of Venezuela and Trinidad is highly probable. He writes page 241 :

From its first settlement Trinidad exported cacao; and that cacao soon gained a reputation on account of its delicious aroma. According to Gumilla it was superior to that of Caracas and other places so much so that the crops were bought and paid for beforehand. In the year 1727 a terrible epidemic spread in the cacao plantations. . . . Here, as in Venezuela, the growers admit two distinct species, or varieties; they are the Creole Cacao (Cacao Criollo) and the Foreign Cacao (Cacao Forastero). Whether distinct species or mere varieties they have distinct characteristics.

At page 243, in referring to *Theobroma cacao,* De Verteuil states that species to be the source of supply for European and American markets, and adds :

It should be considered as the parent stock of all the numerous varieties now cultivated (1884), all of which are the products of hybridism.

The author is inclined to believe that Dr. (later Sir) L. A. A. De Verteuil, K.C.M.G., with whom he had the honour of a personal acquaintance, intended the word hybridism to mean the cross-breeding between varieties, and not hybridism between distinct species, a conclusion the pretext strongly supports, which is in full accord with the views of the writer as to the presence of innumerable varieties of Theobroma.

Whatever the kind was that was cultivated and reported to have succumbed to disease in 1727, it is fairly evident that it was more susceptible to disease than the later introduced "Forastero," and in consequence was less planted in subsequent years. The Trinidad "Criollo" is still much less vigorous than "Forastero," which tends to show that this (the Criollo) was the kind so badly affected by disease one hundred and eighty-two years ago.

To come to the present day, a compilation of the diseases of cacao has been published by the Agricultural Department of Trinidad, April 1909, and by the Imperial Department of Agriculture, Jumelle, Wright, and others in various works.

Wright says in his "Theobroma Cacao or Cocoa": *

* "Theobroma Cacao or Cocoa," A. M. and J. Ferguson, Colombo, 1907.

The number of diseases recorded from countries supplied with botanic institutions possessing mycologists and entomologists is at first sight alarming. There are countries where, though cacao has been cultivated for many years, the records of specific diseases are very scanty; usually the diseases are in existence in such places, but have not been identified on account of the absence of officers engaged in such research.

He also records that Preuss, in his "Tour of Central and South America," found *Phytophthora* in Ecuador; that in Surinam the diseases appeared to him to be similar to those in the Cameroons, and that several diseases have also been reported from Java and Samoa. He adds:

If to these lists be added the names of the fungi collected and examined by Hart, Lewton-Brain, Howard and Stockdale in the West Indies, and by Carruthers and Petch in Ceylon, and the insect pests described by Maxwell-Lefroy and Green, an unpleasant array of pests is before the prospective cacao-planter.

In a paper read before the West Indian Agricultural Conference, *West Indian Bulletin* (vol. i. p. 422), quoting from Long's "History of Jamaica," it is mentioned that probably the first record of disease in cacao was a "blast" suffered in Jamaica in 1671, where, it is reported sixty-five "walks" were destroyed, and following this comes the Trinidad "epidemic" recorded by De Verteuil. Few, if any, records of disease appear to exist which are available to the public for the long interval between 1727 and 1895, when Professor J. B. Harrison sent the writer diseased pods from Grenada, upon which an indefinite report was made. The study of later specimens, however, proved the disease to be of fungus origin. Some of the pods were sent on to Kew, but it was reported that they had lost in transit all trace of the original disease, and had become a dense mass of variously coloured *hyphæ*. Mr. Massee subsequently suggested the preparation of artificial cultures, and these having been successfully prepared were transmitted, with the result that the fungus was determined as *Phytophthora omnivora*, De Bary. Pods were afterwards sent which proved to be also infected with *Nectria Bainii*, Massee n. sp., these being probably the first two cacao diseases scientifically recorded from the West Indies.

The list of fungus pests of the cacao-tree given on pages

80–82 contains most of those which have appeared to this date, but it may be that on further search more will be brought to light. There are, of course, many of the well-known mould fungi which have not been included on account of their practically harmless character. Notes and comments occurring to the writer follow each numbered species appearing in the Table, which are given as showing what each disease can effect, and affording further information on the methods of control which have been found of service. It is to be distinctly understood, however, that there is in all probability no more disease present now than in previous times, but what is present is better known and understood, and the planter is better able to control its spread by adopting methods which have been found successful.

No. 1. "Black Pod" (*Phytophthora omnivora,* De Bary).—This disease has been formerly discussed in the Bulletin of the Botanical Department, Trinidad (1899). It was then shown by the present writer to be due to a parasitic fungus known as *Phytophthora omnivora,* De Bary, a well-known relative of that causing the potato disease. This fungus is specially known in Europe by the attack it makes upon young beech seedlings and many other plants, both in the open air and when grown under glass. It is nearly allied to a fungus called *Pythium de Baryanum,* which causes a like destruction among seedling plants, generally known as "damping off." Both fungi are essentially lovers of moisture, and do but little destruction in dry weather. *Phytophthora* reproduces itself in several different ways, and its *oospores* are capable of lying dormant for as long as four years without losing their vitality. Hartig on "Diseases of Trees," 1894, p. 45: "Its *conidia* (such as are formed on the surface of a cacao pod), are capable of being blown by the wind, or conveyed by animals, insects, or men." Tubeuf, in his work on the "Diseases of Plants," 1897, p. 116, says: "Preventive measures against the whole group of fungi to which *Phytophthora* belongs consist in the destruction by burying

FUNGUS PESTS OF CACAO

No.	Common name (if any).	Scientific names.	Parts affected, symptoms, &c.	By whom first brought to notice and date.	Treatment.
1	"Black Pod" or "Black Rot" (*a*) See Appendix	*Phytophthora omnivora*, De Bary.	Pods. Blackened in first instance, afterwards covered with white matted "mildew." Then complete rot.	Harrison, Grenada, 1895. Trinidad. Hart, 1898.	Preventive only. Pick, bury, burn or destroy by fermentation, all infected pods or portions of pods. Healthy broken shells left on the field rapidly take up and spread disease widely. Spraying may do good, but is in some cases impracticable.
2	"Pod Canker"	*Nectria Bainii*, Massee.	Pods. Perithecia appear as little red points on the surface of pods, and opened shells left on field.	Trinidad, J. P. Bain and Hart, 1898.	Treatment as for No. 1.
3	"Canker" of stem.	*Nectria theobromae*, Massee.	Stems and branches. Red sap oozes from infected part through fissures on bark. Lastly red pin-head dots appear on outside of bark.	Trinidad, Hart, 1900. Howard, Grenada 1901. Found on immature pods, 1909. Identified by Massee.	Burn, bury deeply, or otherwise destroy all infected twigs and branches. Where remedial measures are attempted, cut out all infected parts, and apply tar or other strong antiseptic to wounded surface. This is a wound parasite affecting interior, and cannot be reached by sprays, except when it appears on surface of bark.
4	"Brown Rot,"	*Diplodia cacaoiola*, P. Henn.	Pod rots, showing brown spots, afterwards turning completely black.	Howard, Lesser Antilles, 1901. Lewton-Brain, 1905.	Preventive measures as recommended for Nos. 1 to 3. Cut out all diseased material and dying trees as soon as seen. Tar all wounded surfaces. Collect and destroy all infected pods, even

	"Die Back."	* Botriodiplodia, sp.	Small branches "die-back."	Hart, Trinidad, 1905, 1906, 1908, 1909.	small or partly grown. A pertinacious wound parasite. Probably the cause of root disease.
	"Root disease."	* *Lasiodiplodia* sp., U.S. Dept. Agric.	Whole tree in youthful stages rapidly withers and dies, showing decayed roots.	Stockdale, 1908.	Trees dying of root disease often afford characteristic spores of Diplodia, but there are probably several kinds of root disease.
4a		* *Chætodiplodia*		Van Hall.	
5	"Thread blight."	Apparently many forms, one ascribed to a species of *Coprinus.*	Leaves and small branches.	Leslie, 1906. Hart, 1907.	Cut away all material possible, and spray with Bordeaux mixture, ordinary formula.
6	"Thread blight."	*Pellicularia koleroga*, Cooke.	Attacking leaves and small branches.	Trinidad, A. E. Collens, 1909.	As No. 5.
7	"Horse-hair blight."	*Marasmius equicrinus*, Mull.	Has the appearance of strands and bunches of black horse-hair which attach themselves to leaves and branches.	Trinidad, Hart, 1908.	Little apparent damage has been recorded (1908). Found in the nurseries of the Botanical Department on young cacao plants growing in bamboo joints. Appear to be attracted by partially decayed bamboo.
8	"Witch's Broom."	† *Colletotrichum luxificum*, n. sp.	Causes swelling of the young shoots (*chupons*) into bunches. Pods become hard and become covered with white mildew.	Ritzema Bos. Van Hall.	Cutting out and burning all infected material is recommended. Stem, root, branch, and pod. Tar-cut surfaces, and cut away, so as to allow of strong spray being used for a season. NOTE.—This disease has not as yet been seen in Trinidad. A fasciated growth resembling it is filed in Trinidad Herbarium.

* Probably forms of diplodia.

† A *Colletotrichum* near to this was reported by the Trinidad Department of Agriculture, February 1910.

FUNGUS PESTS OF CACAO—(*continued*)

No.	Common name (if any).	Scientific names.	Parts affected, symptoms, &c.	By whom first brought to notice and date.	Treatment.
9	—	*Calonectria flavida*, Massee.	Attacks branches, stems and pods, side by side of *Nectria Bainii*, on pods, and *Nectria theobromae on stems.*	Grenada, Howard, 1901. Hart, Trinidad, 1902.	Same treatment as for No. 3. NOTE.—*Calonectria gigaspora*, n. sp., Massee, found on sugar-cane, was discovered in Trinidad by J. H. Hart.
10	—	*Stilbospora Cacao*, n. sp. Massee	Branches and twigs.	Stockdale & Hart, 1905, in Caparo Valley.	Cut away and burn all infected parts. This fungus is evidently a lover of damp situations. It has not been recorded as doing appreciable damage to this date (1911).
11	"Shot Fungus."	*Rossellinia Hartii*, n. sp. (?) Massee.	Stems and branches. Has the appearance of black shot, sometimes varying in size.	H. A. Nurse, Trinidad, 1907.	A strong-growing, vigorous fungus, recently found on *Ficus indica.* Apparently destructive, but not common.
12	"Banyan Fungus."	*Eutypa erumpens*, Massee.	Stems and branches of trees, causing rapid death.	Hart, Trinidad, 1898. A. E. Collens, 1909.	No remedial measures can be suggested. It is a wound parasite, common in the virgin forest, where it kills very large forest trees. It is a wound parasite of a dangerous character. Found on cacao in Santa Cruz Valley by A. E. Collens. Specimens examined by writer. Kills large forest trees.
12*a*		*Eutypa phasetina*, Montg.		Hart, 1894.	

13	—	*Macrosporium verrucosum*, n. sp.		U.S.A. Experiment Station Record.	None given.
14	—	*Sterigmatocystis leuto-nigra*, n. sp.	Not yet seen in Trinidad.	L. Lintz in Bull. Soc. Bot. France, 1906, pp. 48–52.	
15	—	*Fusarium Theobromae*, n. sp.			
16	Mould.	Various.	Occurring in cacao houses.	Various.	Mildews cacao when drying where cleanliness and frequent white-washing are not maintained.
17	Pink disease.	*Corticium lilaco-fuscum.*	Stems and branches.	Dominica. St. Lucia, Stockdale, 1908.	Cut off and burn; apply lime-sulphur wash.
18	Scabby Pod.		Pods.	Stockdale, 1908.	"It does not appear to be very common, nor does it seem to occasion much damage."—Stockdale.

19. *Ophiobolus calathus*, n. sp. Massee. On branches. Fredholm, 1908. Probably saprophytic only.

20. *Spicaria colorans* De Jonge is described as causing the well-known "canker" of the stem in Surinam, and Nectria, formerly supposed to be the cause, is referred to the saprophytes. Recently, however, the author has found *Nectria theobroma* destroying half-grown pods in Trinidad. Species determined by Massee.

21. A new *genus* of fungi has been found upon cacao pods in Trinidad. This has been named by Mr. G. Massee as "Hartiella." One *species* only has as yet been discovered, which is described in Kew Bull. No. 1, 1910, as *Hartiella coccinea*, Massee, n. sp.

22. A new Cacao fungus has recently been found in West Africa which Mr. Massee has named *Marasmius scandens*. It is closely allied to fungi causing sugar-cane and banana disease.

Note.—J. B. Rorer, Trinidad, ascribes canker of the stem to the work of *Phytophthora*, 1910 (*Bulletin Dept. Agriculture*).

or burning of diseased and dead parts of host plants, which contain the hybernating *oospores*, by change of crop of infected fields, and by treatment with copper re-agents."

Phytophthora is highly infectious. Once a cacao pod is infected, the fungus permeates the pod by means of the slender fungus filaments called *hyphæ* and, protruding through, appears upon the surface in the form of white mould. The *hypha* is enabled to pierce the epidermis from the inside by the action of a solvent substance excreted by the growing tip of the *hypha*, the protoplasm secreting a ferment which passes out and enables the tip to corrode and dissolve away the substance of the cell-walls. When the *hypha* has protruded from the surface *conidia* or *sporangia* are developed, and these *sporangia* again give rise to swarm cells, which have the power of movement in a drop of water. "When a *conidium* germinates in a drop of dew or rain, the normal process is as follows: The protoplasm in the interior of the pear-shaped *conidium* becomes divided up into about twenty or thirty little rounded masses, each of which is capable of very rapid swimming movements; then the apex of the *conidium* bursts and let these motile *zoospores*, as they are called, escape" (Marshall Ward, p. 280). Each *zoospore* then swims about for a time, and at length comes to rest, commences to grow in about half an hour, and then begins to bore its way again into its host.

"The whole process of germination and the entrance of the fungus into the tissues up to the time when it, in turn, puts out its spore-bearing *hyphæ* again, only occupies four days during the moist warm weather in May, June, and July" (Marshall Ward). It is probable, therefore, that under the conditions of heat and moisture which exist in Trinidad, the organism will have still more rapid growth than in a temperate climate. The average size of a *conidium*, according to the above author, is $\frac{1}{400}$ in. long by $\frac{1}{700}$ in. broad, and the *zoospores* have a diameter of about $\frac{1}{200}$ in.

Possessed of such measurements it is easily seen that a single drop of water gives them as much room for movement, comparatively speaking, as a minnow would have in a mill pond. When the fungus filaments (*mycelium* or *hyphæ*) have become fully developed, many branches begin to form an *oospore* or egg-like spore. This spore is formed in a swelling of the free end of a branch of a *hypha,* and contiguous to it is formed a differentiated branch of the said *hyphæ,* known as an *antheridium,* and between these two organs fertilisation takes place. It has been noted that some 700,000 *oospores* may be found on the surface of less than a square inch. The *oospores* reach the ground in the decomposing part of plants, and it is this fact which has caused us to recommend the entire destruction of all decaying material in so strong a manner from the time the subject was first discussed. Soil containing *oospores* taken from a diseased seed bed is said to have given rise to the disease four years afterwards, and it is therefore easy to see how readily these spores may be preserved in the decaying masses of broken and empty pods so often seen upon a cacao estate.

No previous record can be found showing *Phytophthora* as destroying fruit in the way that it does the cacao pods, its chief ravages having taken place on the leaves of seedling plants.

With regard to remedial measures, nothing has to be added to, or taken from, the former recommendations made under this head, when attention was first called to the matter, the essential point of which was to destroy all infected material as soon as such comes under the observation of the planter.

Phytophthora may readily be cultivated in a nutrient fluid, composed of agar-agar and mucilage obtained from a half-grown pod, sterilised and placed in " Petri " dishes, and its growth can easily be studied in an ordinary " drop culture." In the " Petri " dishes it produces a characteristic outcrop, on the surface of the jelly, of small white

circles. The disease can be at any time reproduced on the half-ripe or full-grown pods from this cultivation.

Fortunately, there are several *saprophytic* fungi which cover up and appear to destroy the *conidia* of *Phytophthora*, and besides these I have noticed a small mite or *Acarus* which completely destroys the whole growth of the parasite from the exterior of the pods. These are probably to be regarded as natural enemies of the fungus, and may help in no uncertain way to prevent its spread. It is quite certain that we are facing no new enemy, but one which has long been present, and one which we have not much cause to fear if proper measures are adopted to secure the destruction of infected material. Persons possessing a microscope may compare the material from infected pods with the drawing of the fungus on the opposite page, which is taken from an illustration in Hartig's work on the diseases of plants, and is reproduced together with others from the Kew Bulletin by Mr. Massee.

It has been found that this disease is largely propagated in the decaying material from the opened pods when left upon the field, as the disease is always more noticeable in the vicinity of such heaps, and one of the first measures to be adopted is that all such material must be moved away or destroyed.

The effect of this disease upon the cacao bean in itself is shown by an experiment made on account of its being asserted that the beans in the interior were not deteriorated by the presence of the fungus in the outside of the pod. It was found that samples of diseased and healthy beans fermented and dried under exactly the same conditions differed materially in weight. In the experiment made, 432 beans from healthy pods weighed one pound, but it took 565 beans from diseased pods to make that weight, which is a loss of nearly 25 per cent.

Phytophthora first appears to the unassisted eye as a delicate white mould on the surface of the part attacked, which allows it to be readily distinguished from "Brown rot." The *conidia*, or reproductive bodies, are ovate, or

egg-shaped, and attached at the broader end to a very slender stalk which ultimately shrivels and liberates them when mature (Figs. 21 and 22). This condition of the fungus is seen on the outside of the cacao pod, and as the *conidia* are produced in immense numbers and in quick succession, it can readily be understood how rapidly the

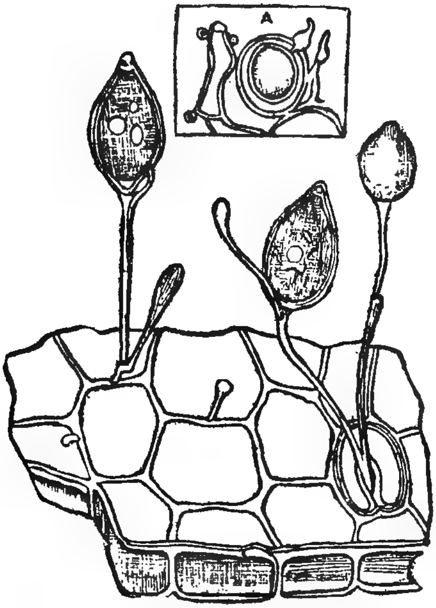

FIG. 21.—Conidia of Phytophthora (× 300).
(A) Formation of an oospore.

pest is likely to spread when they are dispersed by the agency of wind, insects, or by rain. *Conidia* that happen to alight on young pods germinate and penetrate the tissues easily by using the punctures made by minute biting insects, and quickly produce disease. During the period of production of the external form of fruit (Figs. 21, 22, and 23) mycelium spreads rapidly through the substance of the pod, and gives origin to a second form of fruit imbedded in its tissues. These are reproductive bodies

known as *oospores* or resting spores (Fig. 24) which remain in a passive condition until the decay of the pod, when they germinate if conditions are suitable. The bodies

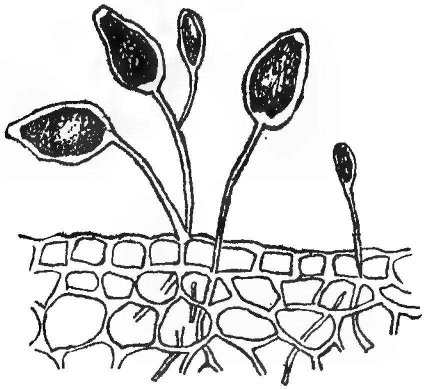

FIG. 22.—Conidia of Phytophthora on exterior of cacao pod, a portion of which is shown in section (× 300).

produced by germination being conveyed to suitable positions germinate again, in their turn enter tissues, and complete the cycle of life by again producing the conidial stage on the surface of the pod.

It will therefore be seen to be highly important, when

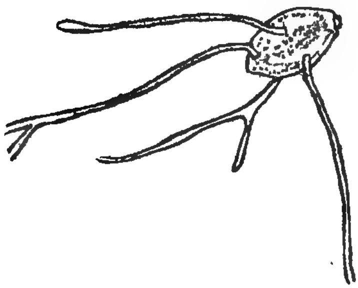

FIG. 23.—Germinating conidium of Phytophthora (× 300).

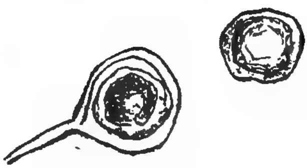

FIG. 24.—Two oospores of Phytophthora (× 400).

carrying out preventive measures, to take special care to destroy every part of the pod, not only that part which

gives rise to the white mildewy appearance, but also that containing the resting spores, as these are capable of remaining dormant for long periods under unsuitable conditions for growth, on or under the ground, and of afterwards producing the disease again when falling on suitable surroundings.

It should be remembered, however, that there is no radical cure for this disease, any more than there is for the treatment of the well-known potato disease, and that the treatment must perforce be either of a preventive character or by selection methods in order to obtain a class or strain of trees which is immune to its attack ; in the same way as has been adopted for control of the potato disease in Europe and America. Bordeaux mixture used as a spray will undoubtedly serve to destroy the *conidia*, but the disease, being internal, and these being regularly expelled day after day for a long period, the impracticability of the method of spraying is demonstrated, as it cannot reach the interior of the pod, and therefore cannot harm the internal growth, which will continue again and again to expel the reproductive organs shortly after any spraying that may be applied. This point should be well understood by cacao planters, as there are not wanting those who for trade purposes will advocate the use of sprays under circumstances similar to those just described, which will not only fail but will discredit the application of sprays where they might be applied to considerable advantage. Therefore, no practice other than that of total destruction, as recommended by the celebrated Russian mycologist, Tubeuf, can be absolutely effectual for exterminating the disease. The best control is obtained by the careful destruction of the pods ; the burying of pods containing the resting spores is only *hiding it for a time*, as the disease will again appear when any of the resting spores are liberated. Fermentation at a high temperature appears to be, on the whole, the best means of destruction of the pods, especially if a free use of lime is made when making up the heaps or tanks for the purpose. The ordinary

compost heap is dangerous, as there will always be the danger of carrying back to the field dormant resting spores, which retain their vitality. The suggestion of establishing concrete tanks in different sections of an estate is an excellent one, and with good management the organic material of the pod could by their use be preserved and returned to the soil as manure or fertiliser. It may be said that this method is too expensive, but it should be remembered that the most expensive method *may*, at the same time, be the cheapest, while slipshod, imperfect and cheap methods are certainly the dearest.

If correct measures are adopted, there can be no doubt, judging from several years' practical experience, that control can be maintained, the spread of *Phytophthora* prevented, and its presence reduced to proportions (never negligible) which will affect but little the annual returns from the field.

No. 2. "Pod Canker." *Nectria Bainii*, Massee.—Mr. George Massee describes this fungus in the following terms :

"*Nectria Bainii*, Massee. *Perithecia* gregaria, mycelio maculiformi flavo-ferrugineo vel aurantiaco insidentia, sphæroidea, rubra, lanosa, demum supra calvescentia, 300–350 *microns* diam. *Asci* cylindraceo-clavati, breviter pedicellati, octospori, 80–90 × 7–9 *microns*. *Sporæ* distichæ oblongo-ellipticæ, utrinque subacutæ, 1 septatae, 10–12 × 5 *microns*, hyalinæ."—Geo. Massee.

This fungus causes the appearance of blotches on the pods, the diseased portion becoming soft and watery, and later on becoming covered with a layer of yellowish rusty or dirty orange mycelium, which is studded over with red perithecia or fruiting organs of the fungus.

The perithecia are often preceded by a small white *Fusarium*-like mould which (from analogy) may be a conidial condition of the *Nec ria* but the connection has not been proved by cultures.—Kew Bulletin.

This disease often occurs on shell heaps in the field, in company with *Calonectria flavida*, Massee, *Phytophthora* and other fungi, but as yet does not appear to have been recognised upon the stems or branches of the cacao-tree. The history of all the *Nectrias* is, however, so suspicious,

that it were well to treat them (until their life history is better known) as a stem enemy, and to adopt suitable means for their destruction. It may be closely connected with the next species (No. 3), but further knowledge is required to make this definite. We know but little of it, and that little is of a speculative character; but it may be shown

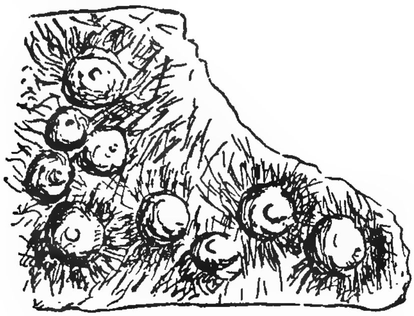

Fig. 25.—" Pod Canker." View of the fruiting bodies, perithecia, on the surface of cacao pods ($\times$ 50).

later that it is also a stem or branch parasite. Figs. 25 to 31 are reproduced from the Kew Bulletin.

The common practice of "breaking" the pods in the fields, and leaving the shells to rot, is largely responsible for the spread of fungus diseases, as it follows that the "breaking places" become centres of infection, and rapidly spread that class of disease through a plantation.

No. 3. "Stem Canker." *Nectria theobromæ*, Massee. —This fungus was drawn attention to in the year 1900, and specimens were forwarded to Kew by the author, where it was determined by Mr. Massee. A description was published in the Kew Bulletin, No. 5, 1908, as follows:

" Nectria theobromæ, Massee,—*Perithecia* gregaria vel sparsa, superficiolia, ovata, levia, glabra, aurantiaco—rubescentia, ostiolo minuto vix prominulo hiante, 0·5 m.m. alt. *Asci* cylindracei, stipitati, octospori, paraphyses septatae, ascos excendentes, hyalini, apice vix incrassato, interdum flexuoso, 3 *microns* crasso. *Sporae* oblique

monostichae, hyalinae, ellipsoideae, 1 septatae, ad septum subconstrictae, 28–30 × 8–10 *microns*.—G. Massee."

This appears to be one of the various species of parasitic fungi that form bleeding wounds in the bark of the cacao-tree. *Nectria Bainii*, previously described as forming similar wounds on cacao pods, differs from the present species in having the perithecia shaggy, with golden-yellow scale-like hairs.

In 1901 Howard investigated a canker disease of cacao in Grenada, and the fungus found was referred by Massee to *Nectria theobromae*, n. sp., and stated to be identical with a fungus sent some time previously by Hart from Trinidad. —Stockdale (*West Indian Bulletin*, vol. ix. p. 170).

It has since that period been found much more commonly in Trinidad, not necessarily because it was really more common, but because more observers were on the look-out for it on becoming aware of its dangerous character. It is often found growing with *Calonectria flavida* on the same surfaces on both stems and pods. The characters associated with it are as follows: It shows as a dark claret colour on the bark in spots (sometimes slightly raised or blistered) which crack and exude a rusty stain. In the fruiting condition, or its "last stage," miniature red "pin-heads" appear, covering a considerable surface of bark, sometimes growing closely together, and at others in scattered patches. It has recently (1909) been found destroying half-ripe pods, causing a warty appearance upon the pods. Specimens were examined and determined by Mr. Massee as *N. Theobromæ*. Few trees attacked by this fungus really fully recover, although the attacked parts may be cut away, treated with antiseptics, and heal up; for even then there is danger of its reappearance at times when the vitality of the tree is again low from any cause. The mycelium of the fungus is able to spread internally, and as the operator cannot be sure that all of it is removed when the excision of the diseased parts is made, there is always great danger of its reappearance. Much depends, however, on the vitality of the trees, some of which appear to heal up and become fairly healthy, while in others, canker breaks out again and again. Prominent vitality is, however, always a bar to the entrance or progress of "canker"; while the converse condition renders them highly susceptible to this and other fungus diseases.

The best known treatment is to excise or cut out the infected parts as soon as detected, treating them with suitable antiseptics in order to induce the wound to heal, and to exclude the entrance of further infective material. Increased attention should be given to the general hygiene of the plantation, so as to maintain the vitality of the

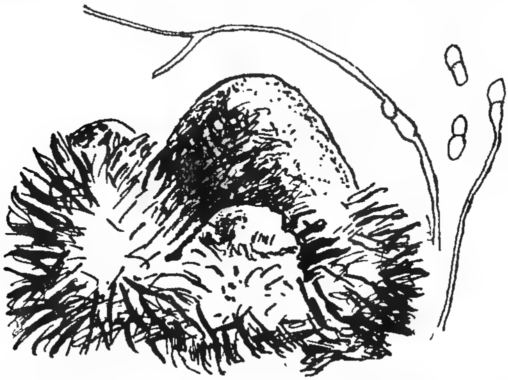

FIG. 26. FIG. 27.

FIG. 26.—" Pod Canker." Three perithecia more highly magnified in different stages of development.

FIG. 27.—" Pod Canker." Germinating spores.

trees at the highest possible standard. If trees are cultivated under too heavy or too light shade they will naturally suffer, and suitable measures should be taken to remedy such a drawback. It is certain that trees too heavily shaded will suffer ; and it is equally certain that trees too much exposed and dried up from the want of shade, will also invite the presence of such disease.

In appearance this disease resembles the standard illustrations by Tubeuf, Warming, Massee, and others, of the nearly related *Nectria ditissima* and *N. cinnabarina.* It causes ultimate ulceration and decay of the bark and stem material, or wood, and has been found on roots by A. E. Collens, who also found it on stems of *Mangifera, Gliricidia,* and *Persea,* 1909. Little good can be done by spraying for reasons previously given ; the number of

spores can, of course, be reduced by regular applications, but by the many the game is considered as "not worth the candle." The best safeguards are: first, destruction of all infected material absolutely; secondly, regular attention to the treatment of wounds, and last, the adoption of systematic hygiene on the plantations, and high-class cultivation. *Sphaerostilbe,* which is considered by Tubeuf to be saprophytic only, also appears on the cacao-tree, and as it belongs to the *Hypocreaceæ,* a division which includes the *Nectrias,* it should be watched with great care. (J. B. Rorer in Report to Board of Agriculture, Trinidad, September 1909.)

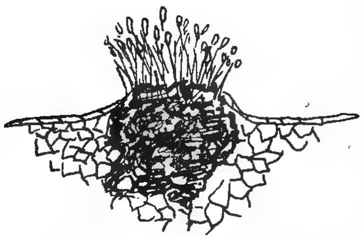

FIG. 28.—A "pustule" of Nectria Bainii breaking through the skin of a cacao pod (× 40).

No. 4. "Brown Rot" of Pods, "Die - back" of Branches, "Root Disease." *Diplodia cacaoicola,* P. Henn; *Botryodiplodia Theobromæ,* Patouillard et de Lagerheim; *Lasiodiplodia,* sp., U.S. Department of Agriculture.—The diseases under the above headings, "Brown Rot," "Die-back" and "Root Disease," appear to be caused by the organism first known to us as *Diplodia cacaoicola,* P. Henn, but to which various names now appear (in the present uncertainty of its full life history) to be attached. The same organism appears to be found in pods, in the branches, in the stems, and in the roots of trees affected by the diseases known under the common names given at the head of this note.

The fungus causing "Die-back" was found by Howard in Grenada, and subsequently was examined in St. Lucia and Dominica. Forwarded to Kew, it was there determined as *Diplodia cacaoicola,* which was reported from Ceylon as causing "Die-back" and "Canker."

Howard describes its appearance in Brown Rot in the following terms:

A circular brown patch makes its appearance, which gradually extends all over the pod and causes complete destruction. Microscopic examination shows that the cells are filled with colourless septate branched mycelium. When the diseased patch on the rind is about the size of a penny-piece, small circular mounds about the size of a pin's head can be seen about the centre of the brown area of the rind, from which a greyish-white powdery dust is expelled which turns black in a short time. This dust is composed of elliptical dark-brown one-septate spores measuring on the average 20 × 10 *microns*. The small mounds are found to be due to the pycnidial fructifications of a fungus in which the spores are formed, which rupture the epidermis and liberate the spores through a small circular opening or ostiole at the apex of the pycnidium."

The same observer carried out many infection experiments on different forms of host, several of which have been duplicated by the writer with confirmatory results.

He discusses the systematic position of the fungus in the *West Indian Bulletin*, vol. ii. p. 195, in which he refers it, as others had previously done, to "*Fungi, Imperfecti*," which means a fungus whose life history has not been fully worked out, and consequently cannot be at present placed under anything but a tentative name. It has been placed by early authors under Fries' genus, *Diplodia*. Howard mentions that a fungus probably identical has been found on sugar-cane, and identified it by cross cultivations with that growing on cacao (*Annals of Botany*, vol. xv., No. lx., Dec. 1901). A. E. Collens reports it on the grape-vine, and *Diplodia maydis* on maize in Trinidad (*Bulletin Agricultural Department*, 1909). Stockdale, in the *West Indian Bulletin*, vol. ix., states that "the 'Brown Rot' of the cacao pod is caused by *Diplodia cacaoicola*, the same fungus that causes the 'Die-back' disease of the stem," and is in general agreement with Howard's previous description. Stockdale and Howard both record the exudation of spores, Howard stating that "they are expelled in the form of white powdery dust," and Stockdale that "small pustules may be seen bursting through the rind of the pods emitting a greyish white powder." Recent experiments in Trinidad have shown, however, that the spores are usually expelled in the form of a spiral thread consisting of the hyaline spores held together by mucilaginous material, which remains while they retain the hyaline form, but disappears

as the spores reach maturity and assume the brown septate form. Cultivation experiments also show that the hyaline spores will germinate, but not so quickly as the mature form, and that the septate or mature spore germinates from both cells while the immature germinates from one cell only ("Studies in Cacao Disease," J. H H., in *Proceedings of the Agricultural Society,* November 1, 1908). A subsequent note of the same publication (February 1909) records that spores taken from a petiole of a coco-nut leaf from the same locality (Trinidad) examined by Stockdale, and in his paper on coco-nut disease, identified by Patouillard as *Botryodiplodia* sp., when introduced into a healthy cacao-pod, produced "Brown Rot" in every particular, thus showing its apparent identity with *Diplodia cacaoicola.* A fungus, again to all appearance identical, has been found on stems of *Castilloa elastica,* and on the root of an orange-tree, and has been determined as *Botryodiplodia* by authorities. *Diplodia* has also been found on a Clusia fruit in the forest, and is said to affect the holly, lilac, chestnut, mulberry, and various conifers in Europe. Howard, it appears, was the first to find it on cacao-trees. There appears in these records strong evidence that we are either dealing with one organism only, or with forms or related genera differing but little one from the other.

In 1906 the author reported the death of young cacao-trees from an organism apparently attacking the roots (*Root disease*). Specimens were transmitted to the Imperial Department of Agriculture and from thence to the Department of Agriculture, Washington, the determination being that the fungus was a species of *Lasiodiplodia,* similar to one attacking cacao and mango in Brazil and San Domingo. Subsequent examination of the stems of young trees killed out by this fungus afford strong evidence of wound infection by *Diplodia,* as its characteristic fructification appeared, and there is nothing in any of the many sets of specimens that show any difference in form, method of attack, or ultimate result which contrasts with the recognised form

and habit of *Diplodia cacaoicola*, and that, if not identical with that species, it is so nearly related as to be without good distinguishing characters for making specific separation. Closer study may, however, reveal the presence of such characters in an organism whose life history is not fully recorded.

Jumelle, in his "Le Cacaoyer," 1899, records a disease attacking cacao as *Botryodiplodia Theobromæ*, so determined by MM. Patouillard and de Lagerheim; and Howard mentions that Engler and Prantl refer to it as occurring in Ecuador. *Botryodiplodia diplocarpa*, Ellis and Everht, was found on orange in Trinidad, 1899. The ultimate determination of the organism or organisms which cause "Brown Rot," "Die-Back," and "Root Disease" must still remain open until the full life history has been worked out, a labour which will probably take some time to complete. Meanwhile, it would appear preferable to refer to it under Fries' name, *Diplodia*. Under whatever name presented, however, it is evident that this disease is responsible for a very large amount of damage on cacao estates in the West Indies, and that its effects are lasting once an estate is attacked. It is a facultative parasite, or one which can exist on dead matter, and is at the same time able to attack and destroy living tissue. It spreads principally by means of its spores, and when we consider that a single cacao pod is capable of producing ten million and more of these, each individual one of which is capable of reproducing disease, it becomes clearly evident that a very deadly enemy is present. While studying the character of the fungus and the methods by which it is spread, it has been observed that the spores of this fungus are capable of germinating and can grow their own diameter in less than an hour, a fact which shows the importance of being able to diminish their numbers with all possible facility. If a wound is made or a branch cut off, and the operator neglects to use antiseptic quickly, there is always the danger that the tree may be infected with disease from wind-borne spores, if such are allowed to accumulate on plantations. Providence is good, however, and has

provided some natural enemies in the form of mites, flies, cockroaches and beetles, and probably many more with which we are as yet unacquainted; and were it not for such natural checks it is fairly evident that this fungus would be able to do still greater damage than now appears, possibly to the extent of extermination. Such natural checks should be studied as closely as possible, in order to ascertain which may be most conveniently encouraged in order to assist in the control of the disease.

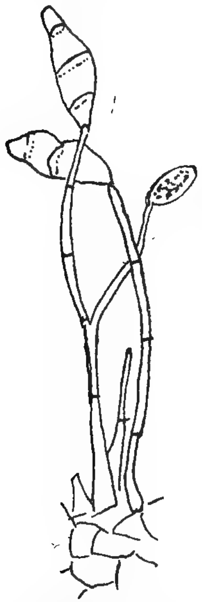

FIG. 29.—A few of the stalks of conidia of Fig. 28 on a larger scale (× 400). *N. Bainii.*

As we know that the fungus can maintain itself on rotten wood, decayed leaves, and pods, &c., there can be no possible question as to benefit to be derived from the maintenance of proper hygienic measures on all estates. Such measures, once generally adopted, should be made compulsory for all planters; otherwise the neglectful among them will reap the benefit of the work of the careful. In the growing season all diseased pods, which never can form mature fruit, should be picked and absolutely destroyed. All empty shells should be dealt with at once as it is proved they can be infected in an hour, and that the disease will spread through a neglected heap in some fifteen days, and produce myriads of spores capable of reinfection. The method of dealing with these pods should be one which allows of the destruction of all living matter capable of germination. Probably fermentation at a high temperature will be the best method, but if this cannot be carried out, some other effectual method should be devised, such as burning or burying, the latter method being unobjectionable in this case, as at present no resting spores have been observed. All dead wood, prunings, &c., should be regularly removed and burned, and all diseased

portions of trees cut away as soon as seen, and destroyed. If such measures as are here indicated are carefully carried out, control of "Brown Rot," "Die-back," &c., can be readily established, and a disease which is a source of great danger may in future be looked upon with composure. It may be pointed out that Howard refers to a root disease as present in Grenada. C. A. Barber (1892–3) also reports a root disease to be present in Dominica, which also attacks other plants, and mentions a similar disease in Jamaica on cacao and coffee. Stockdale (1908) refers to a root disease under the head of *Lasiodiplodia* on the strength (apparently) of a specimen sent by the writer, which according to our examination should be referred to *Diplodia cacaoicola* P. Henn, the same fungus as causes the "Brown Rot" of the pod. At present there appears nothing under the head of "Root Disease" which has been specifically or even generically determined, excepting the specimens above mentioned; which it may be possible to conclude were infected only with *Diplodia cacaoicola*, which may perhaps be shown later to be *Botryodiplodia* and *Lasiodiplodia*, notwithstanding the distinctions at present laid down which separate these fungi. One experiment made by the writer showed the production of a distinct *stroma* containing *perithecia* in colonies, produced by artificial cultivation in "culture fluid," and infected from a cacao pod attacked by veritable "Brown Rot."

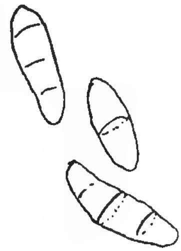

FIG. 30.—Detached Conidia or spores from the pustule (Fig. 28) ×400. *N. Bainii.*

In all writings on "Root Disease" it does not appear that anything has yet been definitely determined, and only preventive and hygienic measures have yet been suggested. It may be, however, that several "Root Diseases" other than *Diplodia* will be discovered attacking cacao, but these yet await the efforts of the investigator.

Nos. 5 and 6. "Thread Disease." 5, *Pellicularia Kaleroga*, Cooke 6, Undetermined.—The occurrence of

Thread Disease was noted by Lewton-Brain as occurring in St. Lucia in 1904. It was afterwards shown at the Agricultural Conference in Trinidad in 1905, and was again found in 1907 in the Sangre Grand district of Trinidad by the author. None of the specimens were sufficient for determination. In 1909 specimens of *Pellicularia* were found in the St. Anne's district of Trinidad by A. E. Collens, were determined at Kew, and subsequent examinations proved this fungus to be not uncommon on rose plants in gardens, but up to date (1911) it cannot be said to be prominent. The determination shows that the specimens collected in 1907 may, with some certainty, be also referred to *Pellicularia*. One of the species of thread blight proved on being cultivated to belong to a species of *Coprinus*. Kew references to *Pellicularia* are to be found in the *Kew Bulletin*, 1893, p. 67. It is stated that it has been recorded from Jamaica, that it appears to belong to South America, and that considerable loss has been sustained in India from its attack. It appears to be readily controlled by spraying with Bordeaux mixture after cutting away the most infected portions. It has been seen on crotons and other garden plants as well as roses. A form of thread disease has been found on shade trees, and the dying branches falling on cacao-trees below have been observed to infect them.

No. 7. "Horse Hair Blight." *Marasmius equicrinus*, Mull.—This fungus appeared in 1907 in the nurseries of the Botanical Department, where it was found covering young cacao plants growing in bamboo joints. So far no special damage has occurred, but it is an enemy whose action and progress should be very closely watched, as it is known to do special harm in many parts of the world.

No. 8. "Witch's Broom." *Colletotrichum luxificum* n. sp. (*Exoascus theobromæ, Ritz Bos.*).—This is a disease present on the mainland of South America, but which, so far, has not been detected in the West Indies. It appears to be a disease of a destructive character, and a close watch is being kept and measures adopted in order to prevent

its gaining admission. It causes the production of bunches of swollen twigs or *chupons*, resembling a broom, to appear on the stems, and the pod is rendered quite hard and useless before it reaches maturity. It has caused heavy loss wherever it has appeared and is one of those fungi against which plant protection laws should be directed in full force. It is reported that a species of *Colletotrichum* resembling *luxificum* has recently been found in Trinidad.

No. 9. "Yellow Canker." *Calonectria flavida.* Massee.—This is a wound fungus generally appearing in conjunction with *Nectria theobromæ* and *N. Bainii.* It was found by Howard in Grenada. Stockdale records that "*Nectria theobromæ* and *Calonectria flavida* may occur together in the same area while at other times they may occur alone." It is not at present credited with a large amount of damage, but it is sure to be found in places where the vitality of the cacao-trees is at low ebb. Inoculation experiments conducted by Howard are recorded as showing that both *Nectria theobromæ* and *Calonectria flavida* are parasitic in character. Treatment therefore should follow on the lines laid down under Nos. 3 and 4.

No. 10. "Branch Fungus." *Stilbospora cacao,* Massee.—This fungus was found on the young growth of a cacao-tree on an estate in the Caparo Valley. It is not specially prominent and has been little studied. It appears, however, to attack and destroy the points of the small branches. Where seen the same measures should be adopted as for Nos. 3 and 4.

No. 11. "Shot Fungus." *Rosellinia Hartii,* Massee.—This fungus was found in Trinidad (Diego Martin district) by Agricultural Instructor H. A. Nurse, in 1906. It has been little studied, but the genus is so well known for its destructive character that control measures should be vigorously adopted wherever it is found.

No. 12. "Banyan Fungus." *Eutypa erumpens,* Massee (?).—The name "Banyan Fungus" arose from the fact of its being first discovered destroying a large tree of *Ficus indica* in front of the Queen's Park Hotel, in Trinidad.

Further study has shown that it is able to kill enormous trees, and once attacked the death of the tree is merely a question of time, as no remedy can be applied. Where the disease is prevalent the greatest care should be taken to prevent air-borne spores gaining entrance through wounds or abrasions to the cacao-tree. Its discovery by Mr. A. E. Collens on the cacao-tree is of great importance, as it shows the danger to cacao which a belt of forest land entails. Many of the largest trees of the forest are brought to the ground by the attack of this fungus and utterly destroyed, and forest belts in which it is present must constitute a permanent source of danger to cacao if they are allowed to stand. The careful planter, however, will take steps to remove infected trees in his wind breaks and shelter belts so as to rid himself of the proximity of such a dangerous wound parasite. The fungus itself may readily be distinguished by the naked eye. In the first instance slight swellings or blisters appear upon the bark, generally circular in form, and varying from half an inch to three or four in diameter. After some little time the raised bark cracks away, and beneath is found a hard black *stroma* or cushion, which contains the *perithecia* and spores of the fungus. To the present time, there is little evidence of its having done any material damage in cacao lands, but one tree being found infected clearly shows that others may become so. It is a wound parasite, and the dressings of cacao-trees should be regularly maintained where there are trees infected with *Eutypa* in the neighbourhood, in order to prevent inoculation.

The fungus is also found in Barbados, some of the old trees of *Ficus lucida* on the Garrison savannah being badly affected. Mr. A. E. Collens has recorded its presence on *Litchee* trees in the Botanic Gardens, Trinidad. In this case the trees were known to have suffered from lowered vitality due to another cause, and, in the opinion of the writer, formed an excellent object-lesson, explaining the

presence of parasitic fungi on trees in a bad condition of health.

It may be mentioned here that even after trees were seen to be fully infected and destroyed by this fungus there were not wanting those who disputed the fact. These were men wholly unacquainted with mycological science, who argued that because they could not see with the naked eye, they could not believe those working with instruments of precision. Such opposition meets the worker but too frequently, and it becomes especially regrettable where the unbeliever has large interests under his control. Science is, however, slowly winning its way. Another and similar species of *Eutypa* is recorded at 12*a*.

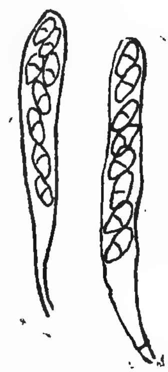

FIG. 31.—Pod Canker. Two asci, each containing eight spores (×400). Each Perithecium (*see* Fig. 26) is a mass of these asci.

Nos. 13, 14, and 15.—These are fungi put on record as being found on cacao. So far they have not been recognised in Trinidad or other parts of the West Indies.

No. 16. "Mould."—In the fermentation bins and drying-houses it requires the constant effort of the operators in charge to keep "mildew" or "mould" from gathering on the surface of the beans, and a great deal of the work of the drying floor is expended on its destruction. In places where little care is exercised, or from want of knowledge, the inside of the roofs of the "floors" may sometimes be found covered with the growth of mould fungi, while the worker is quite unable to understand why mould arises so quickly on his cacao. To the initiated the reason is quite clear. Without going into a long description, it may be mentioned here that all ceilings, walls, bins, tools, baskets, &c., should be regularly cleaned and sterilised with lime and copper sulphate wash, in order to prevent the dispersion of spores of fungi among the cacao beans. They are dangerous to the produce, as accumulating on its exterior, and they also find their way

into the interior, the result being "mouldy" cacao, which is inferior in value to what might have been produced.

No. 17. "Pink Disease" (*Corticium lilaco-fuscum*).—This disease is recorded by Stockdale * as being first noticed in Dominica, and subsequently in St. Lucia. He remarks that it does not at present appear to be of a very serious character, and can be satisfactorily kept in check.

No. 18. "Scabby Pod."—Under this name Stockdale refers to an affection of the pods which has been recorded from Grenada and Dominica, and states that on placing them in a damp chamber fructifications of a species of *Lasiodiplodia* appeared. Pods of this character are frequently seen in Trinidad, where they have been regarded as having a surface scarified by insects, thus allowing of ready infection from *Diplodia* spores. When it is recognised that the single bite of an insect causes the appearance of a spot of the peculiar mucilage of cacao, which is a highly suitable means for affording entrance to the growth of the *Diplodia* spore, it will probably be allowed that the presence of this fungus may always be anticipated where scarification of any kind occurs.

No. 19. Another fungus has been recently found on cacao, prominent by its bright red-coloured *stroma,* from which issue myriads of dark-coloured spores, evidently by propulsion. It has been determined as *Hypoxylon rubiginosum, Fr.* Collected by A. Fredholm.

* *West Indian Bulletin,* vol. ix. pp. 178–188.

CHAPTER X

THE FAUNA OF THE CACAO FIELD

It is of paramount importance that all practical cacao planters should be fully acquainted not only with the various diseases to which cacao is subject, but also with the fauna of the cacao field. This may be conveniently discussed under two heads—Insects and Mammals; and in the following Tables are given the common and scientific names of the principal varieties, brief particulars of the damage done by them, and suggestions for their treatment which will be amplified in succeeding notes:

No. 1. The "Parasol Ant" (*Atta cephalotes* and *Atta octospinosa*).—These insects form large nests in the ground or in hollow trees, in which they grow certain fungi as food, cutting leaves and other vegetable matter into small pieces as material on which to grow their fungi. They carry the cut portion held above the head, often travelling in columns, making a regular path or footway, the width of which varies in accordance with the size of the nest. In the forests of Central America tracks have been noted over a foot in width, and the strength of colonies is such that they are able to strip a large mango-tree of its leaves in a single raid of a few hours, leaving nothing but the bare branches and leaf-ribs. They are common in Central and South America and in a few of the West Indian islands, Trinidad unfortunately possessing the largest stock of them among the British islands. They do great damage on cacao estates, especially to young fields, and on older plantations the whole of the leaves of a large tree may be carried off in a single night if large nests are allowed to develop in the neighbourhood. The insects can, however,

INSECTS

No.	Common name.	Scientific name.	Damage done, if any.	Authorities and date.	Treatment and comments. (See also notes.)
1	"Parasol Ant" or "Bachac."	*Atta cephalotes* and *Atta octospinosa.*	Destroys leaves.	Möller and many authors.	Destructive measures only. Nests should be sought out and destroyed as soon as damage is seen. Use fire, water, tar, carbon bi-sulphide, sulphur fumes. Puddle with water. (*See notes to follow.*)
2	Black or common Ants.	*Formicidæ.*	Not properly ascertained.	Common.	Studies in progress.
3	Borer Beetles.	*A. Steirastoma depressum* and other species.	Cuts channels in stems and branches.	Do.	During breeding seasons the insects are to be found on the stems and branches, and are easily caught. Cut out and tar wounds. (*See notes.*)
4	Do.	*B. Trachyderus succinctus.*	Do.	Do.	
5	Pin-hole Borer.	*Xyleborus perforans.*	Do.	Do.	Little can be done but to cut away and clear all infected material from vicinity.
6	Do.	*Tomicus* sp.	Do.	Do	Do. Do.
	Twig girdlers "Sawyer," "Beetles."	*A. Ecthœa quadricornis*, Oliver.	Cuts small branches, which fall to the ground.	Nurse and Broadway, 1908.	Collect mature insects during breeding seasons. Destroy trees infested in neighbouring lands. Damage formerly attributed to *Dynastes Hercules*, or Hercules Beetle. Collect and burn all dry wood.
7	——	*B. Endesmus grisescens*, Savt.	Do.	Do.	Do. Do.

8	"Root borer" of sugar-cane.	*Diaprepes abbreviatus.*	Damages the roots of cacao.	F. Wallen, 1905.	Catch and kill.
10	Do.	Member of the *Carabidæ* and *Cassididæ.*	Feeds upon leaves.	Nurse, 1908.	Apply Paris green.
10*a*		*Rutela lineola.* L.	Do.	—	—
11	"Scavenger" Beetles.	*Neilus unicornis.*	Useful.	Nurse, 1908.	—
		Parsalus interruptus.	Do.		
		Brentus anchorago	Do.		
12	Beetles found on estates.	*Ancistroma farinosum.*	Cuts leaves.	—	Damage seldom of much importance.
		Brachyomas tuberculatus Chevr.			
		Anchonus suillus, Fabr.	—	—	No special damage yet found.
		Dicornis mixtus, Fabr.			
13	"Dead Pod" Beetle.	*Aræcerus fasciculatus,* De Geer.	Feeds upon the fungus infected material of dead pods.	Hart, 1909.	An insect which lives upon fungus infected material of dead pods, and consequently a spore-destroyer.
14 15	"Leaf Miner." "Pod Miner."	Probably the larvæ of a *Microlepidopterous* insect of the order *Tortricidæ* or *Tineidæ.*	Damages both leaves and pods.	Common.	Little can be done except to pick off attacked leaves. The larva is, however, attacked by a parasitic fly which might be introduced in places where these larvæ are numerous.

INSECTS—(*continued*)

No.	Common name.	Scientific name.	Damage done, if any.	Authorities and date.	Treatment and comments. (See also notes.)
16	"Thrip" or "Thrips."	*Physopus rubrocintas*, and possibly, *Euthrips* sp., and other genera and species.	Damages leaves and pods, the latter especially.	Common in places.	Thrip, or Thrips, is common in Grenada and other islands, but is little seen at present in Trinidad, except in dry exposed situations. Our observations tend to show that it occurs most plentifully in unshaded plantations.
17	"Red Spider.'	*Erythræus telarius.*	Attacks leaves and pods, covering them with web, and giving them a dried appearance.	Common in dry places.	A damp, humid atmosphere is the best preventative. In hot-house culture constant syringing is effectual. "It is not a spider," but belongs to the order *Acarina*.
18	"Cacao Mite."	*Tyroglyphus* sp., near to *Tyroglyphus heteromorphus*, Felt.	This mite with others is found on cacao pods attacked with Diplodia.	Hart, 1909.	Very common in rotten shell heaps, or rotten pods affected with fungi.
19	"Blight," Plant Lice, Green, Red, and "Black fly."	*Aphis* species.	Attack the young growths of branches and the stems of young pods and also flowers.	Common.	To control, use soap water, tobacco water, rosin wash, petroleum emulsion, as a spray.
20	"Pod Hopper," "Cacao bug," "Horn backs."	*Horiola arquata*, Fabr. and other species.	Pierces the stems of pods and allows the ingress of fungi.	Do.	Control with rosin compound, tobacco and soap mixtures, and other common sprays. (*See* "Scale Insects," published by Imperial Department of Agriculture, Barbados, Parts I. and II., 4*d*. each.

21	"Mealy Bug" "Scale."	*Dactylopius citri*, *Lecanium* sp., *Aspidiotus destructor* and others.	Attacks leaf, bark, and pods.	Do.	Do. Do.
22	White Fly or Ant.	*Aleyrodes* species.	Attacks young leaves.	Do.	Do. Do.
23	"Wood Ant," "White Ant."	*Termes* species.	Damage done unimportant.	Do.	Will seldom be seen on healthy trees unless used as a road to others. Affects chiefly trees with rotten stems or branches. The insect feeds on wood infected with fungi.
24	"Mosquito Worm."	*Cutiterebra funebris*, Austen.	Mentioned here as it damages the labourers on a plantation.	Hart, Dec. 1894.	This species has only been found in Trinidad. (*See notes.*)
25	"Spider Web" Insect.	*Embia Urichii*, Forell. *Embia trinitatis*, Forell.	Form white webs, covering trunks and branches, &c. &c.	*Field Naturalists' Journal*, p. 192.	The general result is disfiguration. In all probability the insects are friends.

MAMMALS

26	"Deer," "Biche."	*Cariacus nemorivagus*, F. Cuvr.	Destroys young shoots and pods.	Common	Destruction by firearms.
27	Squirrel.	*Sciurus æstuans Hoffmanii*, Peters.	Destroys pods.	Do.	Do. Do.
28	Rat.	*Mus rattus*, Linn.	Attacks pods.	Uncommon.	Causes little destruction.
28*a*	Common Rat.	*Mus alexandrinus*, Geoff.	Does considerable damage.	Very common.	Causes great destruction of pods on estates. Trap, poison, or shoot.
	Spiny Rat.	*Loncheres guianæ*, Thos.	—	—	Habits as yet insufficiently known in regard to cacao, but habits are arboreal in the first and terrestrial in the second.
	Pouched Rat.	*Heteromys anomalus*, Thompson.	—	—	

MAMMALS—(*continued*)

No.	Common name.	Scientific name.	Damage done, if any.	Authorities and date.	Treatment and comments. (See also notes.)
29	"Manicou" "Gros yeaux."	*Didelphis* species.	Destroys pods.	Common	Is said to do a considerable amount of harm where plentiful.
30	Lapp.	*Cœlogenys paca*, Linn.		Becoming scarce.	These are rodents which are vegetable feeders, and may occasionally be found—in their districts—doing damage to cacao. They are used as game for the Table. No. 30 making a choice dish.
31	Agouti.	*Dasyprocta aguti*, Linn.			
32	Quenck.	*Dicotyles tajacu*, Linn.	Barks, trees, and roots.	Rare.	Of little trouble to the planter.
33	Monkey.	*Mycet s seniculus.*	Where in numbers, does considerable damage.	Common in Central America.	In Central America this animal, with many other species, is very destructive to cacao. In Ecuador the monkey is said to plant the cacao by its distribution of seeds. In Trinidad they are present, but do little damage.
34	Man.	*Homo.*	Very considerable.	—	*See subsequent notes.*

be readily destroyed in several ways, viz., by sulphur fumes driven in by a centrifugal fan or bellows; by pouring coal tar into their nests; by use of bi-sulphide of carbon as a fumigator or explosive in their tunnels, or by puddling the whole of the nest into a paste with water. The attack of a colony of this insect is very insidious, as the insects generally work at night, remaining quiescent during the day; and nests may develop in the neighbourhood of an estate to a large size before being discovered by the night raid which does damage. They should be treated like fires; when discovered "put them out" of existence. Where present, these ants are terrible pests to the cultivator, and those who have had no experience with them can hardly realise the amount of damage they can do. *Atta cephalotes,* or the "house builder," is the most voracious. The members of its nest consist of some eight forms of the insect, respectively: (1) king; (2) queen; (3) soldier; (4) worker major; (5) worker minor; (6) nurse major; (7) nurse minor; and (8) nurse minimus (illustration in the latest edition of the "Cambridge Natural History," by Professor Sharp, from Trinidad material). *Atta octospinosa,* Forell, is a less warlike species, and is chiefly found in the vicinity of dwellings, while *A. cephalotes* ranges the forest and cultivated lands as well as gardens. The soldier form of the insect is able to make a severe attack upon any one who inadvertently steps upon a well-guarded nest, its mandibles being able to pierce easily through a thick woollen sock. In Trinidad a law has been passed to enable control to be maintained over their spread, but they are still ubiquitous. In the swarming season the queens fly abroad, each individual being capable of starting a new nest alone and unaided, and constant watch has therefore to be kept for the appearance of new nests, the detection and destruction of which is no small item in the annual expense of a cacao estate. These insects are among the most destructive pests to be dealt with by the planter.

No. 2. Ants (*Formicidæ*). Many species are believed

to be destructive to cacao, but the evidence, so far, is not of a definite character. It appears fairly clear, however, that some are friends and some are enemies; but the determination of one from the other, in the main, awaits investigation. Barrett, in 1907, mentions the presence in Trinidad of *Tetramorium auropunctatum,* Roger (a small yellow ant), *Prenolepis longicornus,* Latr. (a small active black ant), *Cryptourus atratus,* L. (a giant black ant),

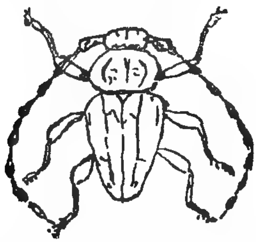

FIG. 32.

FIG. 33.

FIG. 32.—" Borer Beetle," *Steirastoma depressum* natural size.
FIG. 33.—Larva or Grub of the " Borer Beetle."

Camponotus atriceps, Sm. (a brown hairy ant), two species of *Pheiodole,* two of *Azteka,* and also *Odontomachus hirsutiusculus,* Sm., *Ectatoma ruidum,* Rog., and other species of *Ectatoma.*

No. 3. The " Borer Beetle " (*Steirastoma depressum*).—This insect deposits its eggs in wounds, natural apertures or cracks in the bark of branches and stems, and the larvæ, as soon as hatched, work their way with great persistency, cutting spiral channels just beneath the bark of the cacao-tree. Its presence is generally first detected when it has already done considerable amount of damage by the exudation of the *débris* of wood and bark from the opening to the channels. When the larva is small this *débris* does not attract attention, but when it has grown to maturity its work readily catches the eye. The usual method of treatment is to cut away along the channel or tunnel until the larva is reached, destroy the latter, and then tar the wound. The larva may, however, be destroyed by

fumigation with carbon bisulphide, and may sometimes be probed with wire, and the hole effectively sealed with cement or a dry wood plug. Whatever method is used the great object should be to wound the tree as little as possible. It is a curious fact that the attack of the borer is generally coincident with the appearance of fungus disease, and it has been asserted that unless fungus is present the attack of the borer will not be severe. The writer has seen numerous instances where the evidence tended to confirm this view. The attack of the borer is always most prominent on badly drained ground, where the trees are wanting in vitality, and growth not up to the standard. The adult winged insects are readily caught at certain seasons on the stems and branches, especially in the early morning. They may also be trapped by tying a bandage round the stems with opening below, under which the insect will secret itself. The planter should satisfy himself, when an attack takes place, that there are no natural breeding-places in or near his fields, as they infect many forest and economic trees as well as cacao. Fallen branches and stems should be removed from the field and destroyed, as these form hiding-places for the insect, which must be regarded as one of the major pests of the cacao field.

No. 4. *Trachyderus succinctus* is the name of another boring beetle which has been seen to do similar damage.

Nos. 5 and 6. The "Pin-hole" Borer (*Xyleborus perforans*) does but little damage, except where trees are in a bad condition of health and severely attacked by wound fungi. A similar insect known as *Tomicus* species, is another small borer which does similar damage. The attack of these insects may be controlled by maintaining good field hygiene and increasing the vitality of the trees by good cultivation. The removal and destruction of all dead limbs from the trees and from the ground is a stern necessity.

Nos. 7 and 8. "Sawyers" or "Twig girdlers" (*Ecthœa quadricornis* and *Endesmus grisescens*) have habits much

in common. Mr. Nurse, who first traced their history, says: "The female selects a suitable spot and glues her eggs thereto, after which she steps down an inch or so below the spot and cuts a circular furrow or incision quite round the branch and deep into the wood, in fact, deeply "ringing" it. The food-supply is thereby cut off and it gradually dies, and in due course falls to the ground. From this branch the larvæ obtain their supply of food, and ultimately pupate, and rise again as winged insects to renew the attack. The method of control is obvious, viz., collect all cut branches, destroy all beetles seen, and gather up and destroy branches already on the ground. This insect is not common, but occurs in certain districts in Trinidad." Messrs. Nurse and Broadway observed the habits of these insects in the field in Trinidad, 1908.

No. 9. "Root Borer" (*Diaprepes abbreviatus*), first known as doing considerable damage to sugar-cane, also attacks cacao. It was found destroying roots of cacao in 1905 by Mr. F. Wallen, of Arima, Trinidad. It is, however, not widely distributed and the harm it does as a whole is inconsiderable.

No. 10. Beetles of the groups *Carabidæ* and *Cassididæ* feed upon young leaves, but seldom effect any material damage.

No. 10*a*. *Rutela lineola*, L. was recently detected doing considerable leaf destruction.

No. 11. "Scavenger Beetles" (*Neilus unicornis, Parsalus interruptus* and *Brentus anchorago*) are considered to render considerable service in the disintegration of vegetable matter, and in keeping some pests in check.

No. 12. These are beetles found among cacao fields, the life history of which has not been worked out, and they are, therefore, still under close observation.

No. 13. "The Dead Pod Beetle" (*Aræcerus fasciculatus*," De Geer).—A cosmopolitan species of the family *Anthribidæ* has been found in numbers in dead pods in Trinidad. It has been determined by the staff of the Bureau of Entomology, United States, by the kindness of

Professor L. O. Howard, who reports that "It is known to live in all sorts of seeds, fruit and cotton bolls that have been infested by other insects, and in which *various species of moulds are growing*. A very closely allied species, *Brachytarsus variegatus*, lives in North America exclusively on 'smuts,' so injurious to cultivated gramineous plants."

Our observations in field and laboratory show that our species, *Aræcerus fasciculatus*, De Geer, also feeds upon a fungus or smut, viz., *Diplodia cacaoicola*, P. Henn, which causes the brown rot of the cacao pod, and eventually clears such material of all living spores. This has a very important bearing upon the hygiene of the cacao field, for it shows that the danger of infection is largely controlled by the work of these beetles. Planters have long held the opinion that heaps of shells or rotten pods do not always spread disease, and the reason is shown to be the presence of *natural checks*, such as has been found in the beetle which has now been brought to notice, in conjunction with other insects having similar habits. It would, however, be quite unwise for the planter to rely absolutely upon such checks; he should follow the procedure laid down for his guidance by mycological and entomological experts, using the means laid down to the best advantage guided by his own knowledge of existing conditions.

Brachyomas tuberculatus, Chevr., *Anchonus suillus*, Fabr. and *Dicornis mixtus*, Fabr., are small weevils which are also recorded as found in dead pods, large and small, and probably act as scavengers and possibly (as is also the case with *Aræcerus*) as distributors of fungus spores. Our observations on the point in laboratory experiments how that they destroy millions of spores, while they can only distribute the few that attach themselves to the outside of their bodies which, though not a quantity to be neglected, are comparatively of small importance. Studies in a direction which insures a correct knowledge of the life history of the *fungi* and *insecta* which frequent cacao estates must be fruitful of discoveries for many years to come, for it is now fairly clear that were it not for the

natural checks at present known to exist, disease would soon destroy the very best cultivated fields, in spite of any control measures that have been devised. Sprays and other applications are good in their way, and must be recommended in certain cases, but where the danger of reinfection from surroundings is so great as it is in most cacao countries, they can only have a passing effect; but a certain knowledge of Nature's control methods must readily indicate procedure which will be of permanent service and much less costly than the methods advised by those plant pathologists who confine themselves to the application of remedies alone.

Nos. 14 and 15. "Leaf Miner" and "Pod Miner."—The larvæ of these insects bore irregular channels just beneath the epidermal layers of leaf and pod. Whether the same insect affects leaf and pod appears as yet undetermined. So far as our observation instructs us, these larvæ appear to belong to a small lepidopterous insect, probably one of the *Tineidæ.* They disfigure the pods very much but the leaves are less damaged, and it is not apparent that serious harm is done. They have been observed to be attacked by a small hymenopterous insect which carries off the larvæ. As there are openings to the mined channels, it is clear that fungus spores *may* obtain access, but on the other hand mined pods are seen uninfected, and the chief damage at present appears to be disfiguration.

No. 16. "Thrip" or "Thrips."—These insects belong to the *Thysanoptera,* which contain several families and a large number of *genera* and *species.* The most important at present is one determined as *Physopus rubrocinctus,* which has been found doing considerable damage to cacao in Grenada, Guadeloupe, St. Lucia, and Dominica. A similar insect is also reported from Ceylon.

Physopus rubrocinctus is an insect $\frac{1}{25}$ to $\frac{1}{18}$ in. in length. "The adult insect is dark brown or black, with delicate wings fringed with fine hairs. The young, which have no wings, are pale or yellowish green, generally with a bright

red band extending across the abdomen." (Pamphlet No. 58, Imperial Department of Agriculture.) The insects are found on the pods and leaves of cacao in groups or colonies, the location of which is indicated by a discoloured area arising from the wounds made by the insect while feeding. When the attack is severe the injury to the leaf is sometimes sufficient to cause it to fall from the tree, and when an attack becomes general on an estate short crops result. The attack on the pods causes an amount of discoloration which renders it difficult to determine without close examination whether the pod is fit for picking or not, and many pods are picked by the inexperienced which prove immature and useless.

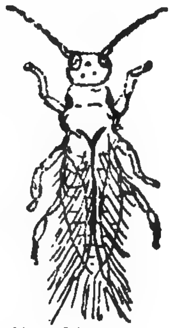

FIG. 34.—Thrip (×25).

In Trinidad the attack of this, or like insect, has not been of an important character to date (1911), but several species of the order are known to be present, and may be found on mature flowers of hibiscus, rose, and other plants in considerable numbers. The damage done to plants by this class of insect is well known to those who have had the opportunity of gaining experience of the "hot house" cultivation of temperate climates. There "thrip" (used as singular and plural) is dealt with by tobacco smoke, tobacco water, and by the maintenance of a continuous humidity of the atmosphere. In Grenada where the worst attack has been experienced, cacao is grown mostly without shade, and the atmosphere is dry, in general. In Trinidad, shade is used and the humidity of the climate is greater, and "thrip" has as yet given little cause for alarm. The inference to be drawn appears to the author to be an obvious one in favour of shade for cacao. A parasitic fungus has been found an effective control for "thrip" on pear-trees in California. For control in Grenada, wash of whale-oil soap, kerosine emulsion, and rosin wash are recommended. An invasion of "thrip" in large

numbers on a rose garden was recently noted. They disappeared in a few days. The attack was coincident with the cutting of an area of bush land in the immediate vicinity. This insect probably belonged to the genus *Euthrips* and comes near to *Euthrips ulicis californicus,* Moulton.

No. 17. "Red Spider," *Erythræus telarius.*—This insect is at times found attacking cacao in unshaded and arid spots. It may be effectually controlled by copious syringings with clean water or soapy wash. It seldom appears except in sun struck spots and spreads little in moist and shaded situations. Thrip has been recorded as an enemy of Red Spider.

No. 18. "Mites" or *Tyroglyphidæ.*—There are probably as many or more distinct species of mites occurring in tropical countries, as in the temperate zone. No satisfactory study of those present in the West Indies has yet been put on record, so that there is little material for comparison. One species has, however, been observed in fungus-infected cacao pods in large numbers, and has been shown by the writer to be a destroyer and carrier of the spores of *Diplodia cacaoicola,* the brown rot fungus. These insects are, therefore, to be considered both destroyers and distributors. It is clear that they destroy, for the microscope demonstrates it from excreted matter. Left to the mites and to small fungus-eating beetles, pods containing millions of spores of *Diplodia,* have in the end been completely cleared of infective material. These mites appear in great numbers in heaps of broken cacao shells, but if these are properly covered, little infection is to be feared from the pile of material left, or from the few spores they may distribute. Far more infection is to be expected from a single dried pod hanging upon a tree where the wind is able to carry its spores day by day into all corners of a plantation. Mycologists and entomologists have hitherto insisted on the absolute destruction of the refuse pods from the field. Many planters have at the same time held the opinion that pods on the ground afforded little opportunity

for general infection. That the practical planter is not so far wrong as was supposed, is now becoming apparent; but until the matter has been thoroughly worked out, it would still be quite unwise to depart from the measures of control which previous expert knowledge has laid down. It is certain that pod heaps are breeding-places for fungi; and it is also certain that infection can take place from such heaps, but until it is further confirmed that there is no, or little, danger from such heaps, planters should clearly adopt the recommendations of the expert pathologist. Our species appears near to *Tyroglyphus heteromorphus*, Felt. (Bank's revision, U.S.D.A., 1906).

No. 19. "Plant Lice." *Aphis* of species.—These are green, red, or black fly, or blight, so common on all kinds of plants. Where they occur on cacao they may be readily controlled by means of sprays of any of the soap or rosin washes, several formulæ for which will appear in a later page. They are said to assist in pollination.

No. 20. "Pod Hopper" or "Cacao Bug" (*Horiola arquata* and allied species) are commonly found in Trinidad and other West Indian islands on the stems and pods of young cacao. They are sucking insects, and do considerable damage to the crop, by causing exudations from the pods which assist the entry of parasitic fungi, and by the actual extraction of sap from their immature tissues, which of itself is sufficient to cause the fall of young pods. In their nymph and adult stages these insects are often guarded by stinging ants, which construct over the *Cercopids* tunnels, for their protection, made up of mud pellets. The ants feed upon certain exudations of the *Horiola*, in the same manner as from those of the common *Aphis*, which are known to allow themselves to be "milked by ants," and thus obtain the name of "ant cows." The species carrying out this process are believed to be *Camponotus atriceps*, Sm., and *Cryptourus atratus*, L. A species of *Azteka*, a very small ant, has been observed protecting *Dactylopius calceolariæ* and "Mealy Bug" in like manner. The "Pod Hopper" can be controlled by the use of rosin wash.

No. 21. "Scale Insects." *Coccidæ* of species. Of these *Dactylopius citri* and *D. calceolaria* have been found on cacao, also *Lecanium oleæ* and *Aspidiotus destructor*. The most common is *D. citri*. When in large numbers they do considerable harm, but at present they must be classed as one of the lesser pests to be dealt with, although they are present in considerable numbers, no fewer than forty-one species being named from collections made in Trinidad, of which thirty were collected by the author. (See "Coccidæ of Trinidad," T. D. A. Cockerell, in Bull. Bot. Dept., Trinidad, 1896, April.) They can be controlled by rosin and other washes.

No. 22. *Aleyrodes* of species are found at times in large numbers. They should be treated as No. 21.

No. 23. "Wood Ant," or "White Ant." *Termes* species.—There are a number of species of these ants or "termites," as they are called, in most cacao-growing countries. They do but little direct damage to the cacao-tree, although they may be present in such numbers as to become a great nuisance, by the accumulation of their nests upon the trees. They affect chiefly trees which contain rotten or fungus-infested material, which constitutes their principal food. The nests can readily be destroyed by the use of small quantities of bisulphide of carbon, poured into holes made in the nest by a pointed iron rod, or in dry weather they can be broken up and burned.

No. 24. "Mosquito Worm" (*Cutiterebra funebris*, Austen.—The common name was given under the idea that the worm was bred from the eggs of a large mosquito. The insect is common in some districts of Trinidad and on the mainland of South America. It is a large fly or *dipterous* insect which deposits its eggs under the skin of animals (man included). The egg hatches and the larva develops, and as it grows causes intense irritation at certain periods. The form of the worm, however, prevents its extraction—the lower part being the larger—except by a surgical operation; for if extraction is attempted the worm is mutilated, and an ulcer or blood poisoning may result.

When left to maturity (seldom allowed in man) it pupates and readily leaves the skin of its host, the wound healing quickly. Finding one of these insects in a rat (*Loncheres guiana*), the author kept the animal in a cage until the insect developed, secured the pupæ, and hatched from it a large two-winged fly, which was afterwards named as *Cutiterebra funebris*, new species (*Annals and Mag. Nat. History*, Series 6, vol. xv. May 1895). When an overseer or other member of the staff becomes infected with this fly, he should at once have it removed. The insect, however, need not be feared, if due attention is given to keep all parts of the body well covered, when resting or sleeping in the open, which prevents the ova being deposited. It is not common except in a few woodland districts.

No. 25. "Spider Web" Insect (*Embia Urichii* and *Embia trinitatis*).—These are insects which form white webs on cacao and other trees. The insect is a peculiar one, and belongs to the *Embidæ*, under which only a single genus is known. It much resembles in form the European "earwig" (*Forficula*). The insect covers the bark with a thick matted white web, which is nearly opaque, but through which may be seen the thicker channels, ways or paths, used by the insects. The web covers, at times, surfaces eight to ten inches square, while at others its diameter will not be more than three inches. They frequently shift their web, and the place of their abode probably depends much on the food-supply present. The web affords protection to them and also their families, which are raised beneath it in a communistic manner. It has been noted that newly made webs are generally constructed over areas covered by lichens, mosses, fungi, and scale insects. An examination of a deserted web shows that in every case the surface of the bark has been beautifully cleared of all vegetable and animal matter, which is strong evidence that the insect is a bark scavenger, and that it does a considerable amount of good. The writer has observed the method of spinning from a collection kept in captivity, and fed upon similar matter as that which is found beneath

the webs. The recognised scientific conclusion is, that the insect spins its web from material contained in its enlarged first joints of the *anterior tarsi* (fore legs). These organs are passed alternately in front of the mouth parts in drawing the thread and spinning it. The thread of the web is, however, of so fine a character that the writer has been hitherto unable to confirm the scientific view, as it appeared to him that the action of the limbs was more in favour of the presumption that the material of the web was drawn and spun from the mouth. The two species are described by De Saussure in the *Journal of the Trinidad Field Naturalists' Club*, pp. 292–294, 1896, which also contains a description of a parasite bred from the insects by Mr. F. W. Urich. The *embids* are very common on trees of all kinds in Trinidad, and especially in the cacao fields. It is quite possible that these insects may also check the increase of "thrip" upon cacao-trees. Having dealt with the principal insects, reference may now be made to mammals.

No. 26. "Deer" (*Cariacus* (*Coassus*) *nemorivagus*, F. Cuvr.).—This very timid little animal is common in the Trinidad forest, but with the extension of cultivation its numbers are gradually decreasing. Plantations near to forest lands, however, are still subject to damage from its depredations, and especially young fields. They can easily be destroyed when they come out to feed in the early evening, or can be hunted with dogs, the latter being a favourite sport. Their flesh, however, is dry, and has not much flavour.

No. 27. Squirrel (*Sciurus æstuans Hoffmanii*), Peters. —This animal much resembles the common English squirrel (*Sciurus vulgaris*), and has similar predacious habits. It does a large amount of damage on plantations by eating holes in the pods, and head money is paid for its destruction, the gun being largely used for this purpose. It may be expedient here to point out that the gun is a weapon which should be very carefully used on cacao estates, as there is nothing which invites the attack of parasitic or wound

fungi so much as a gunshot wound, and the work of destroying animals by this means should only be entrusted to men who know the direct effects caused by wounds of this character. On estates where free use of the gun is allowed to ignorant persons there is sure to be a large number of trees infected by wound fungi.

No. 28 and No. 28*a*. Rat.—There are several destructive *species* of this animal present in Trinidad, some of which are reported to be hybrids of *Mus rattus*, Linn., and *Mus alexandrinus*, Geoffr. *Loncheres Guianæ*, Thomas, is also reported a fruit-eater by Chapman. The greatest damage is done, however, by the common rat, *Mus alexandrinus*, which destroys cacao pods in large numbers. Their numbers have been kept in check of recent years, but Tobago estates still suffer. Control: Poisons, virus, and traps.

No. 29. "Manicou Gros Yeaux" (*Didelphis* sp.).—This little "Opossum," only slightly larger than a rat, does a considerable amount of injury by eating pods. It has recently been determined by Chapman that more than one species is common to the island, one of which he determines as *Philander trinitatis* (Thomas), and another as *Marmosa murina* (Linn.).

No. 30. "Lapp" (*Cœlogenys paca*).—This is a small animal nearly related to the common guinea-pig or "cavy" and is often found upon the woodland estates in Trinidad. It is often hunted for its flesh, which is considered a great delicacy, to which the author can amply testify. A loin orleg of "Lapp" is a dish fit for a king. Although it is a vegetable feeder, it is not common enough to do serious damage.

No. 31. "Agouti" (*Dasyprocta aguti*).—This is an animal of the same class as the Lapp, and is also used for food. Its flesh when cooked has a flavour which is compared to that of the hare (*Lepus*). It does no appreciable damage.

No. 32. "Quenk" (*Dicotyles tajacu*, Linn.).—This animal is the "Wild Hog" of Trinidad. It only appears

on estates surrounded by forest lands, and is seldom found in sufficient numbers to do much damage. It affords good food.

No. 33. Monkey (*Mycetes seniculus*).—This monkey is found in the forest, but is not present in sufficient numbers to do appreciable damage, except perhaps in woodland districts. On the mainland and in Central America several species are known to be especially destructive to cacao, upon which they at times descend in marauding armies. In Ecuador Baron Eggers has reported them as numerous, and has stated that a large amount of the forest cacao from which the supply of produce is drawn is grown from seeds carried by the monkeys into the forest, some of which, falling to the ground, germinate and grow into excellent trees. This fact appears good evidence of the value of shade.

No. 34. Man. *Homo of species.*—Probably more damage is really done to cacao plantations by man than by any other influence except destruction by fungi. The principal damage to plantations is done by the ignorant and careless of the labouring classes. A few years since it was a common thing for members of a cutlass gang weeding a field, to find a resting-place for their tool by sending it sufficiently deep into the nearest cacao-tree to hold it until again to be used. It was a common thing, until recent date, to find branches hacked off with a cutlass, erroneously termed pruning, without regard to the making of a wound, leaving sometimes a foot or more of wood (*ton-kon*) to die back to the main stem, thus causing heart rot of the stem and ultimately a hollow centre. In fact, in the olden time, the utter want of knowledge of the physiology of plant life led to the adoption of what are to-day considered barbarous methods in planting, pruning, and general cultivation. The practice on the cacao estates was of the crudest character, founded upon the "rule of thumb" methods of European and American agriculturists of the olden time, together with many of the traditional customs and superstitions of the aborigines. During the

past three decades, however, wonderful progress has been made all along the line, in fact the tendency now is to follow the teachings of experts without sufficient care to obtain the necessary instruction to make them a success. A planter, informed that phosphatic manures are necessary for cacao, has been known to decide how much to use, upon the principle that two pounds must contain more food than one, and that the more the better, and thus often to apply it to excess, with the result that he is unable to see the expected effect and then promptly condemns the use of such applications. The great want of the cacao interest to-day is skilled labour, *i.e.* men and boys trained in the primary details of agri-horticultural practice, who know how to fertilise a flower, to bud, to graft, to plant, to sow seed, to prune, to drain, to manure, to harvest crop, and to market it to the best advantage. The latter is probably the point in which they are best trained.

There is also a great want of united effort to discuss and put on record for the future all problems of cultivation, so that when a question again arises reference can be made to previous work in the same direction. Single efforts are often greatly discouraged by adverse and personal criticism however good the intention may have been. It is, however, satisfactory to find a "rift in the cloud," and it is now becoming patent that the matter is receiving attention in Trinidad and in many other cacao-growing countries. Much excellent work has been done by the Imperial Department of Agriculture in the distribution of suitable information, and in organising and teaching methods of modern practice for cultivation of the soil, and in general agricultural education. The colonies of British Guiana, Jamaica, and Trinidad, having their own Departments of Agriculture, have secured no little success in meeting the wants of the agricultural interests there, and it is to be hoped that "bread" thus "cast upon the waters" may be found again "after many days."

CHAPTER XI

ROAD-MAKING AND DRAINING

THE laying-out of roads for a cacao estate should always be one of the first considerations of the planter. If the crop he grows is difficult to carry in the first place to the curing-house, and in the second place to the market, it will easily be seen that the expense attending transit must seriously increase the annual cost of working the plantation. In laying out an estate, therefore, the proprietor should reserve traces at right angles to each other for roads to be used for the purpose of collecting his crop, and should select land situated as near as possible to a good main road or railway, so that his produce can easily be placed upon the market.

On estates on the plains, roads are of course easily made, but if situated on the hill-side the work is somewhat more difficult; but still, even then it is better to allow plenty of space and to make good roads at once, so as to give easy access to every part of a plantation. Hill-side roads are not difficult to make, once the principle is understood; but, as with pruning, the work can hardly be described, and is best learnt by practice under the tuition of an experienced hand.

Land taken up by roads is by some planters thought to be wasted, and many are satisfied with planting the whole ground without providing anything which can definitely be called a road. The economy of having a proper system of roads is, however, easily understood, as the loss on the number of trees which would be planted on the land occupied by the road is more than recouped to the planter by the accessibility the roads afford when pursuing any

of the operations of cultivation or harvesting crop. We often see plantations crowded with trees among which the mule or donkey is allowed to struggle with its "panniers" or "crook" when taking off crop, regardless of the many wounds which are made in the bark of the trees, and the diseases thereby induced. Good roads should lie at short distances apart, and animals should never be allowed among the trees. The distance at which they should be made will have to be determined entirely by the lay or aspect of the plantation. In flat land any distance from four to eight chains may be used; the richer the soil the nearer the roads should be together.

As to the material of which roads should be made, little can be said, as it usually depends upon local conditions. If road material is plentiful it is better to make good roads to start with, as working on bad roads and trusting to badly constructed bridges is a most expensive practice. The best procedure which can be recommended is to examine what predecessors have done, and try if possible to improve upon it. A metalled road is, of course, the best and most lasting; but where road metal from hard rock is not procurable, burnt clay or other material should be substituted. In any case, *make good roads*, especially the main roads. In Trinidad, material for road-making is not cheap, except in the few districts where suitable rock occurs. Bridges are not difficult to construct, where there is a good supply of hard wood in the forest which will make lasting bridges; but they are made once and for all if constructed of cement concrete.

In draining, as in pruning and road-making, only general principles can be laid down. All land, of course, requires draining of some kind or another, but no one can give definite instructions for draining an area until it is understood what amount of drainage that particular area requires. Land situated at a low level will, of course, require much more attention to rid it of superabundant water than will hill-side land, and each area must therefore be treated according to its own requirements.

The object of drainage is to rid a cacao estate of stagnant or superabundant moisture. Flood waters from a river, so long as they do not cover an estate for too long a period, do but little practical harm ; indeed, in some districts they are looked upon as doing a large amount of good by bringing down and depositing upon the surface a certain amount of manurial constituents.

Drains made in any kind of cultivation should always be made V-shaped, with a narrow bottom. The practice of making drains with upright sides, which fall in and choke the drain, cannot be too strongly condemned, and can in no case be recommended, and the depth and width of the drains should be regulated by the circumstances of soil and situation. They should never be made straight in coming downhill, as when so made, the wash becomes enormous, especially if the descent approaches an angle of 1 in 20, but in flat land the straighter they are made the better.

The site for a plantation should always be selected where there is a good natural main outlet for drainage waters.

"Under draining" with pipe, rubble, or a bush base is, I consider, utterly useless in cacao cultivation, as it stands to reason that such drains must very early be filled by the roots of the trees (both cacao and shade trees), and that the action of the drains after the first few months will be stopped by the roots finding their way into them in search of moisture. The theory is good, but the practice is quite unsound with regard to cacao. It is different in lands on which cereal crops are annually cultivated, for there the roots seldom or ever reach to the drains during the period of growth, and consequently the drains themselves work from year to year without let or hindrance ; but the principle cannot be effectively applied on cacao estates. The planter should therefore trust entirely to his surface drainage, and make that system do the work to the best advantage.

Draining is of such importance that it should never be carried out without knowing the levels of the estate, which

should be ascertained by a competent surveyor, if the colonist himself is not able to do the work. The courses of the main drains should follow as near as possible the natural fall of the land. The character of the outfall should be clearly ascertained, in case it should be such as would allow a block to occur (not an uncommon thing) which might cause damage to the estate. All drains should be regularly overhauled at stated periods, cleared where necessary, and deepened or graded where required. On most estates the axiom " the better the drainage the better the crop " is well understood. It is, of course, obvious that a hill-side requires little artificial drainage in order to take away water, and such drainage should be entirely devoted to the proper carrying away of storm waters, so as not to allow them to do damage to the cacao fields by carrying away land and trees.

CHAPTER XII

PICKING AND HARVESTING

THIS is a very important part of the planter's work. Cacao should always be picked in a way that will not injure the tree, its branches, or the " cushions " on them, from which the flowers and pods are produced. The tools formerly in use for cutting the stalk of the pod, thus severing it from the tree, twenty years ago, and also to-day, are the cutlass or machete, the knife, and the cacao picker and pruner. The latter is shown by Fig. 35 facing page 132. This is a very crude tool, and can hardly be used without doing some damage to the trees, even by the most careful. As the result of movements for the information of the planter, instructions have been issued, lectures given, and bulletins circulated in many countries with a view to showing that the ill-health of trees on estates is largely due to a continued course of mutilation occurring during the working of estates, and arising from the careless and reckless use of the tools mentioned, regardless of consequences. These consequences have been pointed out, and considerable improvement has resulted, and an evident desire for further information has been exhibited, which, it is trusted, may be followed by useful results.

The cutlass is *par excellence* the favourite and friend of all working in the cacao field. It is made in various forms and qualities, some of which, as in the " razor story," are evidently " made to sell." They have a blade averaging from 16 in. to 18 in. in length, with a wooden handle of some 6 in. The best makers sheathe their blades in leather scabbards, but the commoner makes are carried in the hand, and when resting are often cut into the

nearest tree, as likely to be "cacao" as any other. The superior workman as a rule carries a well-sharpened blade, and with this instrument he severs all pods from the tree within his reach. The cacao-tree bears from buds or points (cushions) on the main stem, from near the ground upwards, and also on the larger and smaller branches. The lower pods, growing as they do from the ground line upwards, are easily removed by either the knife or cutlass, but for the topmost branches a long-handled tool is necessary, as the trees are too slight to admit of being climbed, and ladders or steps are impracticable for general use for many reasons. The picking is done by men, the pods being allowed to fall to the ground, from whence they are collected into heaps, and as a rule opened on the field by men, women, and children. That an advance is being made is shown by the improvements designed and made in the cacao picker by planters themselves. Years ago they cut and wounded with the old picker, but to-day they require something better, and specially designed not to wound the trees.

Fig. 35 shows the form of cacao picker which has been in use for nearly a century, and is still being largely used. It measures from entrance to socket, to the cutting edge, some 5 to 7½ in., in various patterns, and the distance between the extremities of the cutting edge measures from 2 to 3½ in. The forms shown as Figs. 36, 37, and 38 are of similar size, but Fig. 37 is the lightest of the number and is clearly an improvement on the common form. These "pickers" are called by the Spanish "Esgaratadera," and by other names. Fig. 39 shows a picker with the long-handled Esgaratadera at work, and two women with baskets collecting. Great improvements have recently been made in the forms of this tool, and we have now the "Kavanagh knife" and the "Melville Murray knife," both made with movable blades. These have been highly commended. Other inventions, it is reported, will shortly appear. This is very satisfactory, as showing that planters are now fully

alive to the necessity of preventing wounds to the trees. This tool is used for pruning the smaller branches in the upper part of the trees, as well as for picking pods, and it is truly surprising to see the skill with which it is handled by an expert workman, who can with a "steady push or pull," cut away small branches; but it is also clearly apparent how helpless he is to prevent it from cutting wounds in the trees when a slip occurs. The figures of pickers, Figs. 36, 37, and 38, show attempts to minimise the damage which so often occurs, by alteration in the form of the tool. Fig. 36 has knobbed points, with a central V-shaped cutting edge. Fig. 37 is a light flat tool brought into use in Trinidad by Mr. A. L. Agostini, an enterprising young planter, in whose little *brochure,* entitled "Cacao and How to Reap it," it is fully described by text and illustrations, showing the danger arising from the use of the older pickers, and how this is minimised by the use of his invention. In describing it he remarks that "Cuts and wounds among twigs and small branches are but slightly dangerous to the health of a tree, as compared with those made on the trunk and large branches." He also shows that the pod should be cut at a certain point, and writes as follows:

"By carefully examining the stalk, two distinct lines or demarcations will be seen encircling it. The first or that nearest the branch or trunk, is formed by tiny leaflets or bracts, which make their appearance at an early stage of the growth of the flower. These leaflets, the bases of which in joining form a complete circle around the stalk on arriving at maturity, drop, leaving a scar. The second joint or articulation also makes its appearance at an early stage of flowering."

He mentions Inman's description of the fall of the leaf in *Henfrey's Botanical Gazette,* from which he quotes: "The formation of a joint or articulation is a vital process, a kind of disintegration of a transverse layer of cells," and continues: "Though there is no indication of disintegration continuing through the fibrous tissue of the stalk of the

FIGS. 35 AND 36 (ABOVE) AND 37 AND 38 (BELOW)
EXAMPLES OF CACAO PICKERS

fruit, it remains a weak spot, as will be seen by slipping a penknife through it, and it is undoubtedly the spot that most easily cicatrises, and should further proof be needed it can be noted that the small black fruit all drop at this point."

There can be no doubt that Mr. Agostini has directed the attention of his brother planters to a most important point, as a pod removed, leaving the jointed portion attached to the tree, is clearly more likely to heal without fungus infection than one removed quite close up to the cushion.

The point, however, is an old and well-known one, and has long been practised by first-class fruit-growers, who always cull their fruit in this manner, well knowing that the stump of the fruit stalk will afterwards be dropped in a natural manner by the formation of an "*absciss layer*" which sheds the stump, leaving a healed surface not subject to infection by micro-fungi; or, as Mr. Agostini writes: "The small piece of stalk remaining has shrivelled up and dropped, leaving a clean scar."

Since bringing the picker shown in Fig. 37 into use, its designer has improved it by doing away with the hooked portion of his instrument, leaving only the horizontal cutting edge. He states that it is essential to keep this edge "always keen," and on this point there can be no difference of opinion among those familiar with the subject. Mr. Agostini deprecates the reaping of cacao with shears, scissors, &c., for he says, and rightly so, that "in using these instruments the remaining portion of the stem will be squeezed and not 'clean cut,' if the instruments are not extremely sharp."

In the author's opinion, No. 37 picker or knife is a decided improvement on any form previously in use in Trinidad. No. 38 is, however, of more recent date than Fig. 37, its chief point appearing to be the hollowing of the blade so as to allow of its passing more easily under the pod. It is highly spoken of by Trinidad planters, although some are of opinion that it would be an improve-

ment to insert two small studs on the convex side facing the observer in the figure, at a point where two small circles are placed, to prevent it from cutting along the bark of the tree when removing a pod lying close thereto.

Until other and better inventions arise, however, the "cutlass," the "knife," and the "picker" will still be largely used for picking cacao, and all planters should, therefore, train their workmen to exercise the greatest care not to wound the trees. A sharp knife is to be preferred to the cutlass for picking all pods within reach, and it will be greatly to the advantage of the planter to train the tallest of his workmen for this duty, for obvious reasons.

The best improvements in tools will probably be made by the planters themselves, as designs by manufacturers are often non-effective owing to the designer being far away and not fully alive to the conditions under which they have to be used.

The pods or fruits of the cacao-tree should not be harvested until they are properly ripe, and it requires a considerable amount of practice and experience to judge when the pod is fit to be gathered. If collected when over-ripe, or when insufficiently ripe, the quality of the produce is much affected, as it assuredly results in making an uneven sample. Only skilled and careful workmen should be employed, as the planter saves a large amount of picking and sorting if the harvesting is properly done. It is much better to go through the plantation and pick "little and often," and secure good samples, than to pick green and over-ripe together and have afterwards the trouble of sorting the picking to eliminate the inferior beans.

Where there is considerable variation in the kind of pods produced, it is better to sort the pods before shelling or breaking them rather than make a mixture composed of the several varieties of beans cultivated, as these are known to require different treatment during preparation for market. For instance, the Calabacillo strain is known to

FIG. 39. PICKING CACAO WITH A POLE IN TRINIDAD

(*See page* 131)

require different treatment to the Criollo, and the Criollo,* again, a different treatment to that required by Forastero.

The pods when thus collected should be placed in separate heaps. By some cultivators they are left a day or two before being opened, by others they are opened at once and the beans sent on to the curing-house, or "Boucan," as it is called in Grenada. The latter practice would be our choice, as it enables the planter to secure his produce from the weather and from the depredations of rats, squirrels, and the not infrequent cacao thief. In the one case the labour is performed by a few pickers and carriers, and the breaking has to wait until sufficient material is collected for a single fermentation, in the latter more hands are required but the picking of a single day is fermented by itself. On large cacao estates, however, it is almost impossible to gather or harvest cacao without having some over-ripe pods and pods with growing beans among the crop. These should be separated when the breaking takes place and treated by themselves, as such material can never make first-class cacao.

In Trinidad the cost of picking and drying, &c., ranges from 5*s*. to 6*s*. per 112 lb. (*Annual Report Botanic Department*, 1907, p. 22). In Olivieri's "Treatise on Cacao," 3rd Ed., 5*s*. 1*d*. to 6*s*. 3*d*. is given as the usual cost.

On estates suitably provided with drying space the crop can be placed upon the market at the rate of $2·40 or 10*s*. per 220 lb., but in exceptional cases the cost might reach as high as $4·00 to $5·00 or 16*s*. 8*d*. to £1 0*s*. 10*d*. for the same weight, the cost depending much upon the accessibility of the district and quantity and quality of labour available.

A well-known operator reports that he picks and puts into "sweat house" at a cost of 80 cents to $1·20 per 110 lb., *i.e.* 80 cents in crop time and $1·20 when there is little to be picked. On some estates contracts are made for picking

* The correct interpretation of the word Criollo, as used in the West Indies, is "native," certainly not "cross-bred." (*See* Olivieri's "Treatise on Cacao," 2nd Ed. p. 10).

and haulage to "sweat house" for the year at a rate of \$1·00 or 4*s.* 2*d.* per 110 lb. On some estates managers are not allowed to pay more than 60 cents or 2*s.* 6*d.* for the 110 lb., and it is the boast of not a few to show how cheaply they pick. Quick and hasty picking, however, can only be done at the expense of the trees and without regard to certain injury to the "cushions" and to the stems and branches. For cacao to be picked at 50 or 60 c. the pickers must be kept at a trot from tree to tree, and it is absolutely impossible under such circumstances for the men to be careful. Some owners, however, demand that pay-bills shall be small and appear to have little regard for the amount of disease which is produced by this routine. In fact, the rule is—to which I am glad to say there are many exceptions of late years—to "take all you can to-day, and let to-morrow look after itself." Alas! one can readily imagine what havoc is committed among trees where cacao is picked by contract, and to what condition these estates will be finally brought under such conditions. The cost of picking may be detailed as follows, where it is done at about 60 cents per 110 lb.:

	\$
Four men ($1\frac{1}{2}$ barrels each = 6 barrels) at 40 cents a day per man	1·60
Two women to pick up at 25 cents each	·50
One man to make large heap, at 40 cents per day	·40
One man to break or cut 6 barrels ($\frac{1}{2}$ day's work)	·20
Job work extracting beans, 6 barrels at 10 cents	·60
Job crooking to fermenting house	·36
	6) 3·66
	·61

Some planters are of opinion that it pays them better to make an inferior article instead of making a superior one. Now the facts are, that the superior article is one which possesses a higher natural quality, or has gone through a more careful process of fermentation, and the inferior article is one which has been treated to a lesser amount of preparation. There cannot be the slightest doubt that the properly fermented article has the best

FIG. 40. *a a* THE AGOSTINI CACAO PICKER. *b* AN ORDINARY CACAO PICKER

flavour, but if the market demands at times a lower scale of preparation, it may possibly be to the interest of the producer to supply the quality which is in demand, whatever the ideal may be as to superior or inferior quality, but he should nevertheless not lose sight of the fact that a superior article is always saleable, while an inferior article has at times to suffer in price for the want of a buyer.

The quality of cacao, however, depends much more largely upon the special kinds or variety grown than upon the quality of the land or the amount of preparation it receives. Of course, preparation can be well done and badly done ; but, given a bad class of cacao, no preparation whatever could ever make it a first-class sample; it might make it better, but never first class. For instance, all the knowledge of preparation available in Trinidad would not suffice to make a sample of ordinary Trinidad cacao into a sample which could be identified with that of Ceylon or Java, for the reason that the class of cacao itself is essentially different ; and *per contra*, it would puzzle the Ceylon planter to turn out a sample to match that of the best Trinidad unless on estates where the Forastero variety has been introduced ; and Trinidad could only turn out a sample like the Ceylon produce by growing the exact strain (Old Red Dutch) which produces that class of cacao. In the same way no one could possibly produce a sample of cacao in the West Indies from the ordinary cultivated forms, which could compare with that produced by Nicaraguan or Venezuelan Criollos ; for they are entirely different in character, and the beans are larger, better coloured, and higher flavoured.

The latter varieties are now being cultivated, however, and supplies are being sought for further extension, which up to the present have been obtained from the original consignment introduced by the author in 1893. It will, however, be some years before clean samples of these kinds can be available for export, as the tendency is to plant them mixed with other kinds, and thus, although they will infuse certain new strains to Trinidad stocks, the pure

strain stands in danger of being lost, unless preserved by vegetative reproduction ; a fact the tropical planter would do well to bear in mind.

Mention was made in the previous pages of Mr. Agostini's patent cacao picker, by the use of which danger arising from the use of older forms of pickers is minimised. The Agostini picker or "golette" is depicted in Fig. 40 at *a a*, which show it in use and how it prevents damage to the tree; *b* in the same Figure demonstrates how the ordinary picker can seriously wound a tree. Fig. 41, which faces this page, shows the "cushions" of the cacao-tree from which the flowers and fruit spring. It is essential to preserve these "cushions" uninjured when picking the fruit. These two illustrations are from photographs by Mr. J. L. Agostini.

FIG. 41. THE CUSHIONS OF A TRINIDAD CACAO TREE

FIG. 42. NICARAGUA CRIOLLO AND ORDINARY ESTATES CACAO
(*See page* 141)

CHAPTER XIII

SHELLING AND BREAKING

THIS operation, as before shown, is sometimes done in the field and the produce carried home in bags, or the pods are first carried, and then broken at the curing-house. The first practice is the most common, although the latter is more to be commended, as the decaying shells or pods when left on the field are a fruitful source of disease. Economic considerations in many cases, however, prevent it from being done.

The operation of shelling or breaking is done with a cutlass or large knife. A cut is made round the middle of the pod, taking care not to allow the tool to go through the shell so as to injure the beans. The pod is then broken in the middle by a sharp jerk, and the beans are taken out and separated from the fibrous tissue of which the placenta is composed.

In Nicaragua, the pods are generally brought in and broken under cover near the curing-houses, the empty shells being put into yards to ferment, and to be trodden into manure by cattle, pigs, &c. There is thus little danger of the spread of fungoid diseases, as no rotten pods are left on the field. The pods are broken without the aid of either cutlass or knife, by being dashed on a large hard wood log, upon which the operator sits, and the beans are picked out and taken to the sweating-boxes, and the shells carried away by attendant women and girls.

If superior samples of cacao are intended to be made, it is very important that the breakers should be instructed to carry out strictly a sorting process which will separate the ripe from the unripe beans and the different varieties from

one another, for it is possible to make a much more even sample by giving due attention at this stage than by any other means, for from the appearance of the sweet pulp surrounding it the condition of the interior of the bean can be correctly estimated.

Among cacao planters there are many who are well alive to the importance of making improvements in the process employed for curing cacao, but as a rule their efforts are met by strong prejudice in favour of the old rule-of-thumb methods, and any one trying to make an improvement is subject at times to no little ridicule on that account, and therefore it is a hard fight to get improved methods into working order. With the small settler it is doubtful if the classification of produce could be carried out to any real advantage so long as each producer undertakes the curing of his own crop; but were a system of Central Factories established a method of classification could be efficiently carried out, and the general character of the produce greatly improved. Large owners generally hold the view that a system of classification does not pay, owing to the increased cost of labour necessary to carry it out. Whether this is a correct view or not is best shown by the fact that for the markets of the world we always find that we must produce a first-class article to obtain a name, and to obtain a name means to obtain a profit above our competitors; but we certainly can never obtain a name unless we make a first-class article. To make a first-class article in any trade or business is well known to pay much better in the long run than to make ordinary produce. There can be no doubt that many improvements in the curing of produce can be effected if the necessary study is given to the subject, and the curing of cacao certainly forms no exception to the rule. Classification of produce must, of course, be governed greatly by the character of that produce, but even with crops of the most mixed character it is still possible to prepare produce for the market which exhibits a very decided improvement on the ordinary out-turn, by careful selection of the pods

in the field, or, better, by selection of beans during the process of shelling. Selection of a certain value may, however, be carried out by sorting the beans after curing, as is done by many planters.

In preparing cacao for fermentation no beans from diseased pods should be mixed with the healthy and well-ripened produce, for if left with the bulk they will materially alter the sample. It has been found by experiment that such beans only result in cacao waste when finally cured, although they may appear to the naked eye as differing very little from the healthy bean. The experiment was carried out with beans of this description, but not a single bean of marketable description was produced from such material, the beans being shrivelled and wasted and in such condition as to spoil, if mixed therewith, any ordinary, let alone any first-class, sample.

Fig. 42, facing page 138, shows samples of ordinary Nicaragua Criollo (left), and ordinary estates cacao. The two beans depicted between the heaps show the relative sizes. The Nicaraguan bean is twice the size of the ordinary Trinidad. Fig. 43, facing page 148, shows a large heap of picked pods outside the plantation lines. A bearer is bringing in pods to the heap by the bag as a head load. Two men standing are cutting or breaking pods with the cutlass. One woman is extracting beans; and a mule with panniers is loading them for transit to the "sweating" house. Fig. 44 shows pickers and carriers, a heap of cacao, baskets, &c.; and the breakers beginning work. Fig. 45, facing page 152, shows in a typical manner the position of pods upon a tree, the pods being in various stages of growth and ripeness. The variety depicted is the Amelonado form of Forastero.

CHAPTER XIV

CACAO FERMENTATION

THE fermentation of cacao is a subject on which many diverse opinions exist, and planters in different places, even in small colonies, have methods (so-called) of their own.

The Government of Trinidad offered prizes in 1889 for the best three essays upon the subject, which were awarded respectively to Messrs. Chittenden, Crichlow, and Lange, and were published in the *Agricultural Record*, and in an earlier work on Cacao, by the present writer. At the time they attracted a considerable amount of attention and criticism, which brought out strongly the various opinions which prevail among planters as to the most suitable methods for estate use. It was shown that although the details appeared to differ, yet when the resulting samples obtained by each were carefully examined, there was but very little difference in the general result. This is generally found to be in accordance with the class of produce made to undergo fermentation; *i.e.* the class of cacao manufactured or cured, is for the greater part governed by the quality of the class put to cure, than by any differences caused, or produced, by the methods employed.

There is no possible doubt that cacao is improved by fermentation, but nevertheless the effect of this process is limited, and quality cannot be obtained by its use, the basis of which is absent when the operation commences. For instance, no manipulator can give a cinnamon colour and an easy break to Calabacillo cacao by any known method. He may improve on its original condition, but he cannot in the words of the old adage, "make a silk purse out of a sow's ear."

Cacao simply dried and unfermented is sometimes in demand on the market; but, in general, well-fermented cacao takes precedence, and the higher the quality the better the price. It follows, therefore, that where suitable conveniences exist for carrying out the process, fermentation is regularly adopted, and unless special calls arise, the preparation of unfermented cacao is left to those who are not prepared with suitable apparatus to carry out the fermentation process.

There can be no question that the result of chemical examination has paved the way for closer determination of the changes produced by fermentation than formerly existed, and progress has been made; but the inquiries as yet do not appear to have affected to any considerable extent the quality of cacao as seen upon the market. The reason for this probably rests in the unlimited amount of variation which exists in every cacao-growing country, and in the quality of the primary produce obtained from the field, especially in those countries where mixed strains have been induced by the importation of cacao of different character. In Trinidad, the original native Criollo of the forest has been completely dominated by the Forastero introduced from the mainland of South America; and again the quality in general of the produce of the island has been largely improved by introductions from Venezuelan estates where the Venezuelan Criollo is the prominent type. The produce of estates will vary therefore in quality in exact accordance with the strain of cacao grown, entirely independent of any method of preparation or fermentation, and the produce of such estates should not be credited as quality produced by the manipulator in the fermenting bins and on the drying floors, but instead to the individual quality of each particular strain.

There is probably as much original difference between cacaos as there is between the crab-apple and a "golden russet," or between a quince and a "Jargonelle pear," and one might as well try to give "body" to a thin wheat grain, or weight to an oat, by preparation methods, if they

were not original varieties having weight qualities, as to make a common strain of cacao into high-class produce.

That a certain change and improvement is brought about by the process of fermentation is a well-recognised fact; but that change depends far more upon the original or special qualities contained in the bean than upon any chemical change produced or caused by fermentation as induced by the planter.

No method of this kind yet known can change the purple colour of a bean into the ideal cinnamon of the manufacturer, and no system is yet practical, which can change the bitter flavour of some beans into the flavour of No. 1 cacao. In the same way, beans of a class without aroma can never be made under any condition to produce the aroma of high-class cacao by the practice of fermentation. The "break" of cacao is less difficult, and more may be done for improvement in this point than in other directions, but the effect is taken to be more mechanical than chemical, yet even in this, little can be done with a hard solid purple cheesy bean to bring it into "class form" with the higher grades.

The fact is that the original and special quality of the beans in their primary ripened state is the chief or ruling factor leading to the finished appearance and quality of the final product.

That being so, it would appear to be advisable to seek out varieties which make under ordinary practice high-class market produce, and to maintain a pure strain of them, rather than to grow a mixed strain of innumerable varieties of varying quality, and then attempt to manufacture it into high-class produce. Such attempts are sure to fail, and time and money will be wasted. There should be greater confidence between the grower and the manufacturer, and it would be far better for planters to confine themselves to certain selected classes than to grow the interminable mixtures that they now put upon the market, which show on being cut and examined that they have a range from the highest to the lowest quality. A country

may grow a certain quality, or strain, and yet in that very strain itself will be found numerous varieties. It cannot be doubted that fine mixed strains exist on many West Indian estates, but they might be far better, and would become of greater value, if selection and vegetative reproduction were adopted, instead of the propagation from seed which surely gives immediate rise to variations of many kinds.

The white-seeded varieties of Nicaragua, Venezuela, and Trinidad, require but a short fermentation to acquire a fine colour, aroma, and flavour; and quality in other cacaos may be readily traced by difference in the beans, starting from white or straw-coloured interiors and loosely laid cotyledons, gradually increasing in colour until a deep purple is reached, with hard compact cotyledons. The lighter-coloured represent high class, the dark purple the lower, with harsh flavour, little aroma, and "cheesy" break. J. R. Martin reporting to the Planters' Association, Ceylon, in 1891, has a paragraph as follows:

"The break of West Indian growths, so far as I have had an opportunity of observing, was invariably very dark brown or purple; which indicates that the cacao is of the Forastero variety, and every cacao planter knows that no care or curing will alter this characteristic."

In general this is correct, but it is quite possible to find pods with all the external appearance of typical Forastero which sections of the bean will prove to be closely related to the Criollo types by the light-coloured beans which appear, and from such pods there is no difficulty in obtaining a break and aroma which compare to some degree with that of the Criollo type.

In some countries cacao is washed, but in the West Indies this practice is seldom adopted. The forms adopted for "sweating boxes" vary according to the facilities afforded for keeping them under cover. In Grenada, concrete tanks are used on some estates, but wooden boxes in form of cubes of 3 to 4 ft. are the common kind in Trinidad. These are built of stout planks, and provided

with a grating at the base through which the liquid products of fermentation can pass away. One side of each of the boxes is fitted with loose planks fitting in a groove at either end, in order to allow of handling the cacao conveniently during the process. The beans are placed in these receptacles *en masse,* and are turned sides to middle, and top to bottom, when the temperature rises too high. Thermometers as a guide to temperature are the exception in Trinidad, but the temperature under the best manipulation is not allowed to rise beyond 120 F.; still, the results where instruments are used or not used, are quite comparable, the management of the process being generally well understood.

It has been held that the operation of fermenting is simply one of malting, and by others that it is the destruction of the vitality of the bean that is of the most importance. A recent writer, Dr. J. Sack, in Bulletin No. 10 of "Inspectie van den Landbouw in West Indié," Surinam, 1908, after discussing in a lengthy manner the chemical aspect of the question, sums up the contents of his paper as follows:

"While curing cacao fungi enter the pulp, setting up alcoholic fermentation through which the sugar of the pulp is split up into alcohol and oxygen; the alcohol is by admixture of the oxygen of the air further oxidised, forming vinegar, during which process a considerable amount of heat is developed. This constitutes the external fermentation. When the temperature reaches about 45° C. the germinating powers of the beans are destroyed. As soon as this takes place the internal fermentation sets in, which is an enzymic fermentation process causing the *cacaonine* to be split up into *Theobromine acetrose,* cacao red, and cacao oil."

The aim of cacao-curing appears, therefore, to be threefold; first, to change the nature of the pulp, thereby ensuring the "keeping" of the cacao; secondly, to develop flavour; and last, to change the character of the interior of the bean to a state which will facilitate the operations

of the manufacturer by giving it what is known as "a good break."

Under the title of "Contributions to the Knowledge of Cacao Fermentation," a brief synopsis of Dr. Sacks' paper was made in English by A. Fredholm, Esq., of the Botanical Department, Trinidad, and published in the Bulletin of the Department for April 1908, in the introduction to which the writer, as editor, remarked that it was of considerable interest to cacao planters, as explaining much that was previously mysterious in the "rule of thumb" methods generally adopted in the curing of the cacao bean. The writer also expressed opinion (to which he still adheres) that although cacao is improved by fermentation, the quality depends more upon the special variety cultivated than upon any method of fermentation which can be employed.

It is well understood by the experienced planter that some varieties of cacao take longer to cure than others, that some are more bitter in flavour, and that some have a more tender skin than their neighbours. He knows at once that beans of the Criollo type do not require nearly as much time to "stew in their own juice" as Forastero or Calabacillo, and he knows when each has reached the proper stage of preparation needed previous to the final drying, but the why and the wherefore of the variation of time in reaching this stage is, the writer believes, still a matter of doubt even among the most able. That the difference in the thickness and composition of the membranous texture of the outer covering of the bean bears a material part in influencing the time necessary for fermentation cannot however be doubted.

The cacao bean, of course, possesses a living principle or embryo like all other seeds, and it is well known that this principle can be easily destroyed, both by exposure to dry air and also by an excess of moisture. The greatest care is always taken by cultivators to avoid an alternation of wet and dry periods when putting seeds to grow, as it is known that this means sure death to the embryo in the first stages of germination, for once a seed has started to

grow a short dry period readily kills it, and so also does an excess of moisture. In the fermentation of cacao we find operators adopting both methods which are destructive to the vitality of seeds, for it is certain that the vitality of the embryo of the cacao must be completely destroyed before it can become cured cacao. The cacao-bean, however, does not need fermentation for the purpose of destroying its vitality, for simple drying invariably destroys the germ. It is a well-known fact that seeds from many members of the same family are very difficult to preserve for any length of time, owing to their vitality being easily destroyed by contact with the air.

Therefore it is not simply the death of the embryo which is needed, neither is it the "malting" process which has been considered by a few as the basis of the process of curing. To malt a seed it must germinate and grow, and its starch must be changed into sugar. It is not necessary, however, to allow the cacao bean to germinate at all to produce a good sample, for, though a fair sample may be made of germinated bean if the process is not too far advanced, it is much better that the bean should not germinate to the extent which allows the radicle to pierce the testa of the seed, though it is certain that cacao may be much more quickly cured if germination is allowed to take place previous to fermentation, as the absorption by the passage or outlet pierced by the radicle would be much more rapid, but the testa, once pierced by the radicle opens the way to easy destruction of the contents by giving access to the spores of microscopic fungi, and the produce is seldom of first-class quality.

Probably the most important consideration in the different methods of "fermentation" is the creation of a certain amount of absorption through the testa or skin of the bean, which is secured by most methods. A certain amount of heat is required. Some may make use of sun heat, others use the heat of fermentation induced in various ways, while others again use both. Small quantities are best fermented by being put into a tin vessel and then exposed

FIG. 43. BREAKING PODS AND EXTRACTING THE BEANS

FIG. 44. A GROUP OF PICKERS, CARRIERS AND BREAKERS
(*See page* 141)

to the sun to start the fermentation. In Trinidad the method by which good results are obtained is known by practice to every intelligent cacao planter, but there are still some differences in the handling of beans during fermentation.

In Aublet's "Plantes de la Guiane" the writer finds the process of fermenting the produce of *Theobroma guianensis*, Aubl., described in the following words:

> Pour conserver l'amande du cacao, lorsque le fruit est dans sa maturité parfaite, l'on rassemble auprès d'une cuve la récolte qu'on en a faite; on coupe par le travers la capsule en deux portions pour en tirer la substance, et les amandes qu'elle contient, qu'on verse ensemble dans la cuve. Cette substance sous vingt-quatre heures entre en fermentation, ensuite se liquéfie et devient vineuse. On laisse les amandes dans cette liqueur jusqu'à ce que leur membrane ait brunie et qu'on reconnoisse que leur germe soit mort; car la bonté du chocolat dépend en partie de la maturité du fruit et du degré of fermentation que l'amande a éprouvée par ce procédé. Les amandes se séparent avec facilité de la substance qui les enveloppait, et sechent bientôt. La liqueur vineuse est un peu acide mais bonne à boire; mise dans un alambic et distillée elle donne un esprit ardent, enflammable et d'un bon goût.

This may be freely translated as follows:

> To preserve the kernel of the cacao, the fruit, when ripe, is cut in halves, and the kernels it contains are thrown together into a vat. The substance surrounding the kernels ferments within twenty-four hours, then liquefies, and becomes sour. The kernels are left in this liquor until the membranes have become brown, and the germ is known to be dead, for the quality of chocolate depends on the maturity of the fruit and on the degree of fermentation it has undergone. The kernels or nibs separate easily from the substance surrounding them and dry by degrees. The sour liquor is acid, but good to drink, and an ardent spirit can be distilled from it which is highly inflammable and of a nice taste.

This shows that the practice of fermentation was known long years ago, and that this species of cacao (possibly a different variety from our Theobroma cacao) was used for producing chocolate. Aublet's work was published in 1775, or a hundred and thirty-six years ago. It is curious to compare the conclusion arrived at by the late Dr. Chittenden, viz., "stewing in its own juice," with the sentence: "The kernels are left in this liquor until the membranes have become brown," and to note their similarity, and also his remarks as to the death of the germ, and the destruction of vitality within the seed, both of which were conclusions arrived at previous to finding Aublet's description of the process. It has been said by

some that we "cannot add anything to the chemistry of cacao." The thorough inquiry into the subject by Prof. J. B. Harrison has, however, shown us the changes that take place during fermentation, and further experiments will possibly show the exact temperature required for the proper fermentation of the bean.

The writer is inclined to think from experiments personally carried out that the heat which occurs during fermentation is not so necessary for preparation as is generally believed. When ascertaining the weight of fresh pulp surrounding the beans, it occurred to him to place the "skinned kernels" and the pulp that had been removed from them together and to allow them to ferment. These were placed in a confined space and allowed to stand three days or seventy-two hours, and the temperature was only that of the outside air or a mean of 80° F. Fermentation had taken place and the smell and taste of the liquor instead of being sour, was sweet and agreeable, resembling very much the smell of the "wort" when the brewing of ale is in progress, showing plainly that diastase was present, probably produced by the alteration of the albuminoid and saccharine substances contained in the pulp, or in the bean, or by the pulp and bean conjointly. The office of diastase appears to be to effect the conversion of a portion of the starch of the bean into dextrin, and thus to render it soluble, for we know that the same process takes place in the malting of grain, but the process here differs, from the fact that germination is not required to take place but should be prevented. Malt differs from barley inasmuch as it contains more dextrin and soluble substances, but rather less starch, cellular matter, and insoluble albuminoids, and a smaller proportion of inorganic constituents; and that there is a similar difference between the unfermented and fermented cacao bean admits of little doubt.

The kernels of the beans which were placed with the pulp assumed the much desired colour (the cinnamon red) which it is the ambition of the planter to produce, in the short space of seventy-two hours, when it is probable that

if they had been fermented with the skin on it would have taken three or four times as long to have secured the same colour to the kernel of the bean. The bean, when thus treated, is liable to mould very rapidly, but in break, colour, and aroma, it was all that could be desired in a high-class cacao. It would hardly be practicable, however, to treat cacao on the same lines in large quantities, nor would it be desirable, but the experiment adds something to the knowledge of the process which has so long been followed.

An examination by the author of beans fresh from the pod showed the following :

		Oz.
Total weight from inside pod—No. 1		3·75
Weight of pulp and testa or skin of seed removed	1·65	
Kernel (clean)	1·75	
		3·40
Loss during operation		·35
Total weight from inside pod—No. 2		5·40
Weight of pulp and testa or skin of seed removed	2·40	
Kernel (clean)	2·40	
		4·80
Loss during operation		·60

The pods were ripe pods, and the entire contents were removed from the shell after it was opened and then carefully weighed. After weighing the pulp, the testa or skin of the seed was removed and the waste and cleaned bean again weighed as above. It will be seen that the pulp surrounding the bean, with the placenta, weighs nearly the same as the cleaned kernel, and shows the weight of easily fermentable material present.

The skin or testa of the bean, after having allowed the changes caused by fermentation to happen to the kernel through its membraneous texture, is finally useful in preventing the ingress of the microscopic fungi or mould, which would destroy the interior parts, the toughened covering acting as an efficient preservative of the interior once it is properly cured. If not properly cured the testa or skin cracks, fungus spores enter, and the interior becomes mouldy and rapidly loses quality.

The temperature maintained in the sweating-boxes has been variously stated. In the Prize Essays it was given as 100° F., rising to 118° and 120°, which, from frequent personal readings under different conditions I believe to be the average heat which can safely be developed. In very large fermenting chambers the heat rises somewhat higher, but there is danger in allowing it to rise above 120°, as the quality of the produce is sure to suffer. Frequent turnings have to be undertaken to prevent too high a rise in temperature.

Professor Harrison undertook in 1897 a long series of analyses involving some three hundred or more operations, which he kindly allowed the writer to publish in his "Cacao," 2nd Ed., 1900, and he has again permitted it to appear in the present pages. These analyses show clearly the constituents of the fermented and unfermented bean and the changes made by the operation.

Although the detail of procedure in fermentation varies considerably, taking one estate with another, yet it is found that there is a great similarity of results obtained, the length of time required for each estate being found by experiment and continuous practice. Practice tells the planter the exact condition to which he must bring his beans before he attempts to dry them, a decision greatly assisted by cutting sections of the beans under treatment, in order to ascertain how far the fermentation has proceeded and whether it has been regular and general. To describe the condition in writing is a difficult task, and that of the late Dr. Chittenden, which is one of the best extant, is adopted. He says : "At this stage, if fermentation has been properly established, the cotyledons are found separated, and the vinous liquor of the pulp, which passes through the membraneous covering, occupies this space as well as the cavities between the convolutions." This it is which has so marked a physiological influence and affects its flavour, the bean being, as may be said, "stewed in its own juice." What is here described is, the writer believes, literally true, and unless we can stew the bean in its own juice, or absorb

FIG. 45. CACAO PODS IN VARIOUS STAGES OF GROWTH AND RIPENESS
(*See page* 141)

the constituents of the pulp through the membraneous covering in some manner, we shall never properly ferment cacao and certainly cannot improve the character of the interior of the bean.

The above may be taken as the condition to which the bean is brought by the moist fermentation of cacao, but there are other methods used which produce similar but not equally good results. Dr. Chittenden says also: "The *conuquero* puts up his beans to drain and forthwith exposes them to the sun for, say, five or six hours; then, heaped and packed up they sweat afresh until the following day, when they get five or six hours more sun, and so on." Again, "Another contrivance of the small grower is that of bagging the cacao at the end of the day whilst still hot from exposure to the sun and to sweat it during the night." This may be called the dry fermentation of cacao.

Some kinds of cacao take longer to ferment than others. For instance, the Nicaraguan Criollo is completely fermented in forty-eight hours (*a well-authenticated character*), and if kept longer in the boxes rapidly blackens and spoils. The Calabacillo varieties sometimes are given ten to fourteen days before they are considered to be ready for the drying house. In fermenting, merely to remove the pulp of any variety some forty-eight hours will be sufficient, and the interior of the bean, except in the case of the thin-skinned Criollo, will be little changed, the break will be hard and "cheesy," and the sample will be classed as unfermented. There is little doubt that the difference in the thickness and membraneous texture of the bean bears a material part in influencing the length of time necessary for efficient fermentation. It has already been shown that the testa once pierced by the radicle is injurious as allowing access of fungi when completely cured, and that germinated cacao takes up the juices of fermentation much more quickly than unpierced beans; yet that the latter have a means of absorption through their testa or covering is apparent from their readily taking up the juices or liquors

present during fermentation and, in fact, " stewing in their own juice."

On many of the finest Trinidad estates and on the mainland of South America " clayed cacao " is prepared for the market by coating it with a thin covering of fine clay. The clay used has been described by a well-known chemist as " a very fine ferruginous clay, free from organic matter. The portion soluble in hydrochloric acid consists mainly of ferric oxide, with a quantity of alumina. The insoluble portion is a mixture of silica and pure clay, *i.e.* silicate of alumina." *

The loss of weight during fermentation has been found to be as follows. From experiments made at River Estate, Trinidad, under the writer's direction, it was shown that the loss during fermentation is 14 per cent., and the loss in drying 56 per cent., and the total loss, calculated on the first weight, 62·5 per cent. The percentage of marketable cacao produced from the raw material, therefore, shows 37·5 per cent. A similar experiment was carried out in the island of Dominica, under the auspices of the Imperial Department of Agriculture, and the results published in the *Agricultural News* show that under their trial the loss was found to be 4·5 per cent. lower than in the Trinidad experiment. It was to be anticipated that some such variation would occur in making such experiments at different places, and it is thought that the difference is due mainly to variation in humidity, and the difference in the water contents of the cacao beans operated upon, points which might easily be determined if deemed necessary, by laboratory experiments devised to show the actual water content of the different samples used. Our experiments were carried out on two separate lots, the first weighing 2600 lb. and the latter 2722 lb. of " wet " cacao, or cacao beans in pulp fresh from the field.

Many experiments have been carried out to ascertain the best form of " sweat-box " or fermenting bin. One of

* " Bowrey in Cacao : How to Grow and How to Cure It," D. Morris, 1882.

the best devices seen was that of a large quadrangular or cubical box, made to contain some twenty cubic feet space. A stout square wooden shaft of hardwood ran at an angle through the centre, entering from one corner and passing to the opposite one at the other end. The shaft was fitted to run in suitable bearings, and to one end was attached a crank or wheel enabling it to be turned little or much or completely over and over in the manner of a barrel churn, thus giving it a motion that, acting with the shape of the box, would stir the entire contents at will, or fix it in a certain position for any length of time. The box is provided with strengthening cleats on its exterior, suitable hinged doors or sliding shutters through which it can be filled, and the contents examined and removed when necessary, a few beaters fixed to the shaft in the interior, and sufficient holes for allowing the fermentation liquors to escape when desired. The box can be readily filled and emptied, and the juices produced can be preserved for manufacture into spirit when fresh, and when stale into vinegar, if the quantity justifies such procedure with these waste products. Cacao vinegar and cacao spirit can be manufactured, both of which have a value which is, perhaps, not fully appreciated. Our knowledge of them was obtained by carrying out both operations, which we did with considerable success. Another form of sweating-box has recently been seen doing excellent work, and is a decided improvement on the older form of tanks and bins. It is constructed in *vat*-form, and when in place may be likened to a huge bucket turned upon its side. It has suitable separate openings for filling and emptying, and can be turned by gearing and crank, in the same manner as a barrel churn, or it can be moved slowly and fixed at any angle required to secure a proper mixing of the contents. These are looked upon by the planter who has them in use, as securing a great saving in labour and as securing economy in time, by some forty-eight hours over the tank system. These fermenting vessels were made by Marcus Mason and Co., New York.

A description of the details of the process of curing cacao of high quality may be of value, and I give that prepared for the Bulletin of the Botanical Department by Mr. J. C. Augustus, the manager of the Trinidad Government Estate, whose samples took first place for the best bag of cacao at the Trinidad Agricultural Exhibition of 1905, and who continues to secure best prices in the market. The class of produce made by this method is "clayed cacao," but, leaving out the addition of the powdered clay, the system is that generally followed for making No. 1 cacao on Trinidad estates, and may be followed with advantage in the preparation of any class of cacao, allowing, of course, for known facts in original grades of produce to be treated. The account given is somewhat condensed from the original, facts of local interest only being excluded.

In the preparation of cacao no hard-and-fast rules can be laid down with any certainty of their being followed out. A great deal depends upon the methods adopted during changeable weather to carry out the principles of general instructions. Sometimes "clayed" cacao is in demand, sometimes "No. 1," or "Fine Estates," or "Good Ordinary," and at other times, unfermented cacao, according to the ruling of the markets. The cacao to be treated is taken to be that of an ordinary estate possessed of strains showing a preponderance of Forastero with a blend of Criollo and Venezuelan varieties.

Cacao on its arrival from the field is placed at once in the sweating-boxes, being thoroughly mixed up in the handling. Put to ferment on a Saturday, it should be turned on the following Tuesday and Friday, and taken to the drying floor on Monday, thus giving a clear nine days' fermentation.*

When turning the beans, care should be taken to see that the top beans go to the bottom, those from the sides to the middle, and those at the bottom to the top. This assists in obtaining an even ferment. A sample thus treated will be observed to show a clear mahogany colour,

* For Criollo varieties four clear days will in general be sufficient.

and upon opening a bean, instead of its being hard or "cheesy," as is the case with unfermented material, the interior will have the appearance of leavened bread, *i.e.* having air spaces separating the cotyledons of the seed and traversing the entire bean. It is thought by some that to ferment for eight or ten days is somewhat risky, but the practice has been followed for several years with uniform success on the Trinidad Government estate. It should be noted that a well-fermented sample has less mucilage and moisture about it and takes only about half the time to dry required for an unfermented one.

As soon as the cacao is placed upon the drying floor from the fermenting bins, the "hands" should be started to clean it, picking out all waste and removing all inferior material. When this is complete it is left with the dryers, whose duty it is to keep constantly walking bare-footed through it, turning it with their feet in a simple manner, thus allowing each bean to get its share of sun, the beans covering the floor in a layer of not less than three, nor more than four inches in depth, so that they do not dry too rapidly. In wet weather the planter is compelled to take every opportunity to dry his beans as quickly as possible, unless artificial appliances are available. One of the chief points in drying is to take especial care to see that the floor is well dry before spreading cacao upon it, for if the planter has a dry floor to work upon, the cacao can remain longer in cloudy weather without danger of spoiling. As the operations proceed, the floor should be repeatedly dried by moving the beans to heaps every two or three hours in order to allow the sun to dry the uncovered spaces, for if the floor is permitted to remain damp from contact with the cacao, fungi or mildew is sure to be produced.

In fair weather, the second day after first exposure on the drying floor, is the best time to apply clay; as the pulp surrounding the beans will have become somewhat sticky, but not too dry to prevent the clay adhering. The red clay used for this purpose is found in quantity on several estates. It should first be well dried in the sun,

and then pulverised in a wooden mortar, reducing it to fine dry powder, which when sifted will be but little coarser than wheat flour when it is ready for use. Dry powder is always used under our method, but some operators advocate its application dissolved in water; but in our case this method has never given as good results as when applied as powder. To apply the clay, the beans should be gathered in heaps of about two barrels * each, and workmen be chosen, whose weight is not more than 120 to 130 lb. each, to "dance" or tread upon the top or apex of the heaps, barefooted, while women and boys, sitting around the base of them, repeatedly throw up the beans as fast as they are thrown down by the dancer. While this is proceeding the powdered clay is applied by dusting it over the beans with the hand, distributing it as evenly as possible over the heap. The exact amount to use cannot be accurately stated, and how much to apply to give the required character can only be learned by experience, but the standard may be fixed at some 3 lb. to the barrel of cacao. It will be noted that the clay readily adheres to all beans which are moist or gummy. On first making the application the beans should not be "danced to a polish," but just enough to allow of an even distribution and covering by the clay. The heap should then be opened out and allowed to continue drying. The following morning it should be again "danced," when the beans will be found much drier than on the previous day. The heaps, while the second dancing is proceeding, should be kept thick under the feet of the workmen, and the process should be continued until the beans are highly polished, and have assumed the appearance and colour of mahogany. To retain the polish the heaps should be opened thinly on the drying floor, and allowed to receive the full action of the sun for some five or six hours. When there is little or no sun available it is difficult to retain this polish on the beans, and it then fades and becomes dull. After this operation there is nothing left to be done except to

* The barrel used is the American flour barrel holding 196 lb. flour.

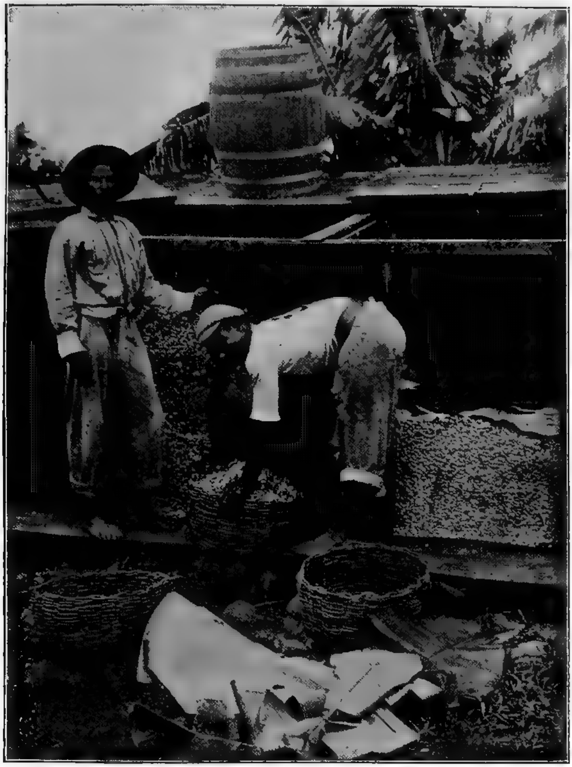

FIG. 46. CURING CACAO IN GRENADA

continue the drying process until the cacao is ready for market.

The following are the advantages and disadvantages attending the " dry " and " wet " process of claying cacao :

(1) When used as a dry powder, the clay assists in drying the beans, as it absorbs moisture and helps to " cut the gum " or to dispose of the mucilage adhering to beans.

(2) It is easier to obtain a good polish with dry clay than by other methods.

(3) The sample prepared with the dry powder runs less risk of being damaged.

The disadvantages of the wet method are :

(1) There is a risk of damaging a sample once partly dry, if it is again wetted ; for if unfavourable weather sets in, it is difficult to get it dry again.

(2) Clay adheres better under the dry method.

(3) The operator cannot get as good " polish " with the wet as with the dry method.

(4) A much larger number of beans will be crushed while " dancing " under the " wet " method.

In fair weather a sample treated by the dry method should be cured and ready for market in four to five days.

After dancing has been performed, the floors should be at once scraped with deck scrapers to remove the mixture of clay and mucilage which collects upon it during the operation. If this is not done the floor will be observed to be quite damp on the following morning, and the quality of the cacao will suffer.

Cacao prepared by this method keeps better owing to the clay and mucilage forming a thin protective covering which prevents the attack of *micro-fungi ;* and it carries better, as the strong covering of clay and mucilage renders it better able to stand pressure consequent on the accidents of transit. That the method is appreciated by the buyers is shown by the fact that estates producing it are always able to obtain good prices.

The expense attending the process here described is so little above the cost of ordinary methods that it well repays

the planter and the income of an estate is considerably increased by its use.

In connection with the fermenting bins the novice will probably find considerable trouble at times, owing to the entrance of contaminating organisms in the form of moulds and other fungi, which cause discoloration of the fermenting material, and ultimately affect the colour and quality of the marketable product. He should not wait until they appear, but should maintain the strictest hygienic measures in the boxes and all their surroundings. The experienced planter never uses an "old bag," "tarpaulin," or covering of that kind, but carefully goes to the field and provides himself with clean bundles of banana or plantain leaves to line and cover the cacao placed in his sweat boxes, in order to prevent the attack of microscopic fungi, and when his boxes are emptied they are at once cleaned, scraped, and given a coat of lime wash; the drainage is examined and care taken that the underside of roof and ceilings are all treated to a coat of wash. Once fungi enter they are hard to suppress, and it is far cheaper to keep them at a distance by a proper observance of hygienic measures.

On the floors where drying takes place the same condition of extreme cleanliness should be observed, constant attention to which is better than all the remedies which can be afterwards recommended.

CHAPTER XV

DRYING APPARATUS, ETC.

UNTIL recent years the ordinary sun-drying floor formed the principal means of drying cacao after fermentation. Sir William Robinson, G.C.M.G., while Governor of Trinidad in 1890, wrote a small pamphlet on the drying of cacao, and tried to interest proprietors in methods of artificial drying, and after stating that the crop of Trinidad for that year showed a total of 14,000,000 lb., he said: "Yet there are not half a dozen artificial drying houses, if as many, in the whole colony." The crop for the year 1909 amounted to a total of no fewer than 51,575,109 lb., and yet artificial dryers are still few and far between, although some progress has been made, the following being some of the most successful attempts in this direction:

(1) *Hot-water heating.*—In Trinidad the first attempts at artificial drying were made with a plant constructed after the manner of the ordinary horticultural method for heating plant-houses in Europe. It was tried on two estates, but had few imitators and is gradually going out of use.

(2) *Steam heating* was then tried, and in one or two cases it met with considerable success.

(3) *Tray drying* in an iron-cased machine was next tried. The machine was made and erected by a London firm, but was not taken up by planters as it was considered unsuitable. Good cacao, however, was made by this apparatus.

(4) *Rotary dryers.*—These have been erected in one or two places in Trinidad, and users report that they have done excellent work. The machine made by John Gordon

and Co. (Fig. 47) has now been working for several years, and has often saved cacao from being spoilt in wet weather. The makers claim that this machine dries cacao ready for market in twenty-four to thirty-six hours at a cost of sevenpence per bag in the dry season to two shillings in the wet. The machine is made in several sizes, and consists of a rotating cylinder driven by steam-power, the cacao being dried by passing hot air through the mass, which is contained in various sections of the machine, the air being heated to the necessary temperature by the exhaust steam. In the illustration on the opposite page, *A* is the drying cylinder containing the cacao. *B* is the heater where the air is heated by the exhaust steam from the engine. *C* is the fan. *H H* are the pipes conveying the heated air to the drying cylinder. *S* is the pipe conveying the exhaust steam from the engine to the heater; and *T* is the pipe for the escape of any surplus exhaust steam. It is reported that quite a number of these machines are working successfully, in Surinam, Venezuela, Trinidad, Grenada, St. Lucia, Jamaica, Hayti, Peru, Bahia, Samoa, the Cameroons, and the Gold Coast. The writer has had the opportunity of seeing this machine at work, and can vouch for the fact that it turns out an excellent sample of cacao.

The following is a condensed note of a reply to our inquiry, received from a large owner in Trinidad as to the working of the machine. He reports:

(1) The machine is most useful, and the one on our estate paid for itself the first year it was put up. (2) The cost of drying is about the same as for sun-dried cacao. (3) The cacao is well and soundly dried, the wooden drum making a better quality of cacao than a metal one. (4) The capacity of our machine is about ten bags at a time, but it will take twelve, and then takes proportionately longer to dry. (5) Cacao is dried in thirty-six to forty hours; and (6) I would strongly recommend planters making over five hundred bags per annum to invest in one. It may rain for a week at a time and the drying process

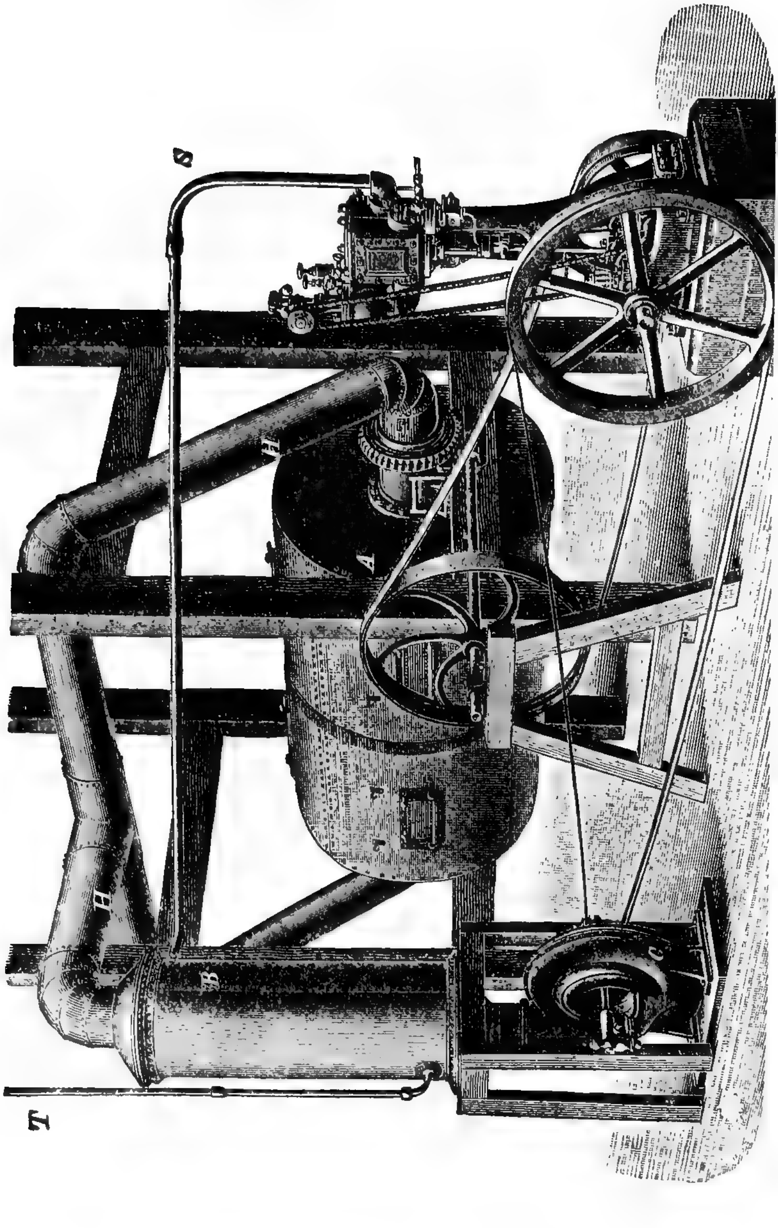

FIG. 47.—A rotary cacao-drying apparatus.

need not be interrupted for a moment, the machine going night and day. It turns out perfectly dry and sound

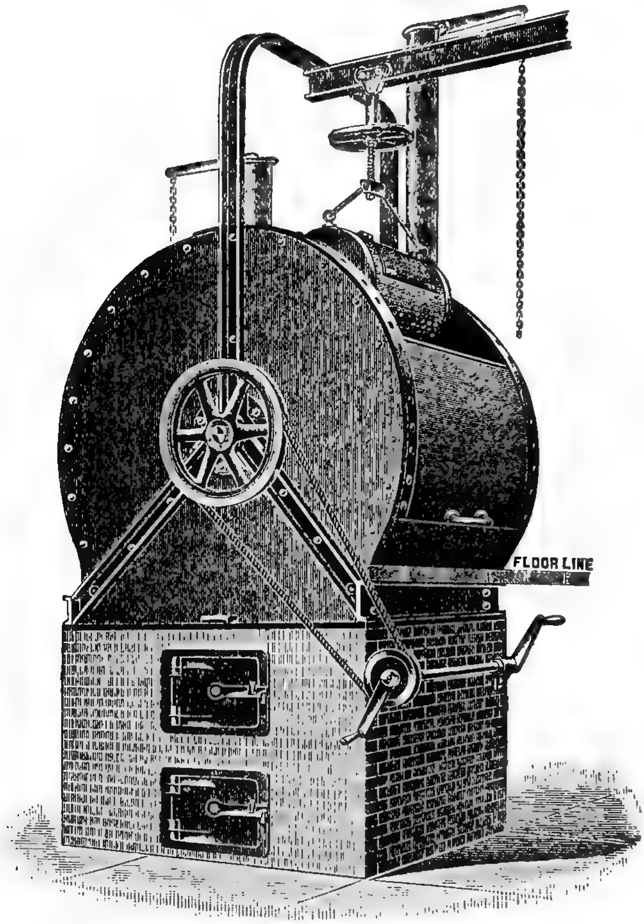

Fig. 48.—The Hamel-Smith rotary dryer.

cacao, which weighs more in proportion to bulk than the sun-dried.

This information speaks for itself, especially as the machine has been working for successive years. It is

made in sizes to take from 2000 to 10,000 lb. weight of wet cacao.

Another rotary dryer of different construction called the Hamel-Smith rotary dryer, has been placed upon the market. It is claimed by the inventor that this apparatus (depicted by Figs. 48 and 49), which is manu-

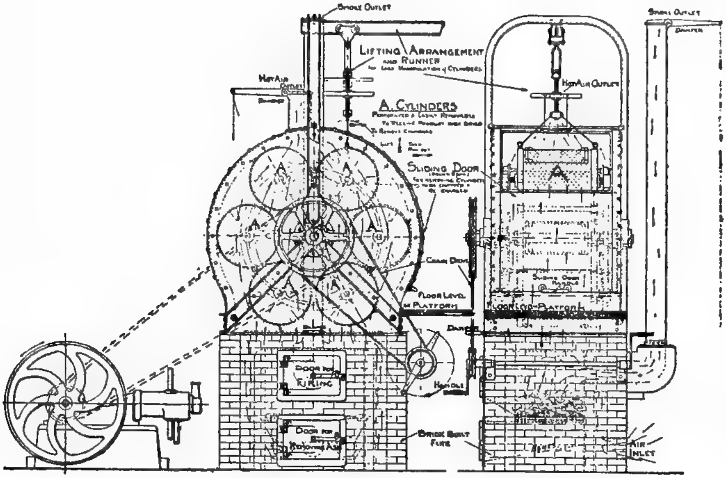

FIG. 49.—Section of the Hamel-Smith rotary dryer.

factured solely by David Bridge and Co., Ltd., is suitable for drying cacao, coffee, copra, &c. The principle of this dryer is a revolving frame carrying six cylinders, some 3 ft. in diameter, and made of any length, in accordance with the size required, to take from 2000 to 10,000 lb. of wet cacao or other material. The heating surface is supplied by a kiln floor situated above a suitable furnace. The motive-power can be supplied by hand, in the case of the smaller sizes, but the larger must be supplied with power movement. This dryer promises to furnish a simple and economic method for drying cacao with facility and despatch, while securing excellent quality in the market product. Fig. 48 shows the exterior of the apparatus, which is strong and compact; the furnace, or lower portion, being sunk below

the floor level. Fig. 49 gives a sectional view of the dryer, and also shows the various processes by which the air is admitted and expelled together with the moisture from the product under treatment. It is only necessary to add that practically any fuel can be used, and that the makers claim that the fumes cannot possibly come into contact with the produce. The movement of the dryer is continuous, but too gradual and gentle to damage the contents of the cylinders, marked A. These cylinders are supplied in duplicate, so that whilst one set is in use the others can be refilled to take their place without loss of time or firing. The furnace is constructed of brick or like material, and can be fired by ordinary fuel, waste material, or oil.

Rotary drying in any case promises to be the most successful method of treating cacao in its preparation for market, but the system is not new by any means. In 1865 a suggestion was made to the Scientific Association of Trinidad that cacao could be conveniently dried in cylinders exposed on a platform during the day, and supplied with artificial heat during the night, in a building with movable roof. The suggester, Mr. Thos. Law, wrote: "In the day, solar heat may be utilised for drying; in the night heated air drawn through a series of pipes, that run to and fro through the house under the revolving cylinders."

Another system was brought to notice by the late Mr. W. S. Tucker, in 1884, in a paper read before the Trinidad Planters' Association, in which the principle is also rotary, or in Mr. Tucker's words: "The cacao is caused to revolve around a heated tube," but this does not appear to have been taken up.

(5) *Vacuum dryers.*—A machine of this kind, made by George Scott and Son, Ltd., is depicted in Fig. 50. The makers claim it as being an effective dryer for cacao. The apparatus consists of a heavy cast-iron chamber, heavily ribbed to withstand the pressure of the atmosphere, when at work. The ribs are not seen in the illustration, being obscured by the non-conducting composition with which

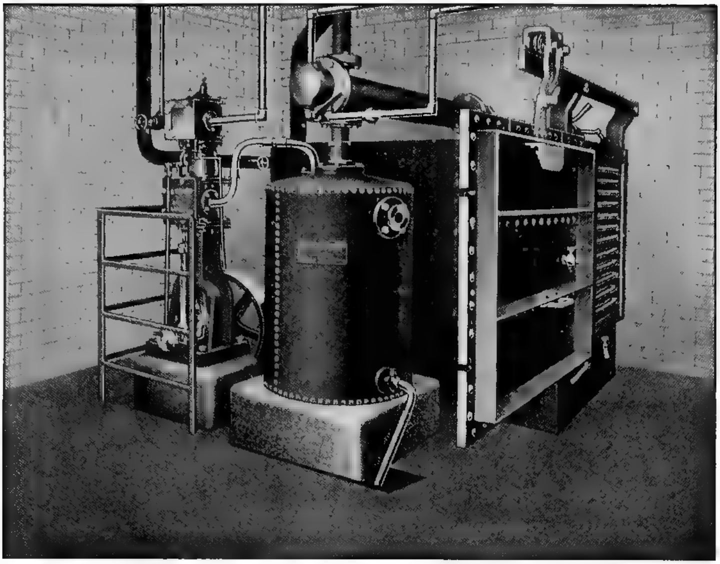

FIG. 50. SCOTT'S VACUUM DRYER

FIG. 51. HOADLEY'S KILN DRYER

the stove is covered. A sliding overhung door closes the apparatus, and makes an hermetically sealed chamber. The interior of this chamber is fitted with a number of steam-heated shelves of special grid type so constructed that the steam must equally search every portion of the shelf. Their method of action is also special to this make of apparatus, inasmuch as the steam joint is outside the stove and not inside as in other makes. This remedies the liability to leakage and consequently the atmosphere in the stove itself is a particularly dry one, and this conduces more than anything to a rapid even drying. These steam-heated shelves are all controlled by one valve, steam being admitted equally to all of them, and at the same time. This may be exhaust steam, and where such is available forms a further economy. The vacuum is produced by means of a steam or power-driven vacuum-pump absorbing from 1 to 4 horse-power, according to the size. The vapour which comes away from the stove is led in a single vapour pipe to the condenser, which is a multitubular two-flow condenser, where it is condensed by means of cold water, and the water thus formed is conducted into the receiver, which prevents moisture reaching the vacuum-pump. The beans are usually placed on nets, or perforated trays, and are then inserted between the steam-heated shelves, so that they are heated from both above and below. It is, of course, usual to prepare one set of trays to recharge the apparatus the moment those which are being dried are ready for removal. The time occupied varies from two to six hours according to the state of the bean.

(6) *Kiln dryers.*—Several dryers described by Preuss are mentioned by Wright in his work "Cacao," page 135. In Trinidad, Hoadley's apparatus, as depicted in Fig. 51, is of the heated floor type. A plant was erected in Trinidad and was seen working by the members of the West Indian Agricultural Conference held in Trinidad in 1905, and was described in the July issue of the Botanical Bulletin (Trinidad) for that year. The building which contains the apparatus is some 35 ft. square. In its upper chamber

a circular floor is laid, with guard edges about 1 ft. in height. This floor is pierced with numerous small holes leading through into the lower storey. Beneath the floor is fitted a funnel-shaped air-tight chamber, the pointed base of which reaches nearly to the ground, and into the base of this inverted cone is fitted a conveniently sized pipe for conveying hot air, generated in a chamber (containing pipes filled with exhaust steam) through which cold air is drawn by a powerful centrifugal. The air is thus heated to any desired point up to 150° F., and is then forced through the funnel and floor into the drying chamber. The latter is covered with a cone-shaped roof, with vents at the apex to allow of the escape of air moistened by its passage through the beans resting on the floor. From the centre of the floor an upright shaft ascends to the apex of the roof. This shaft carries two or more booms moving horizontally, quite close to the floor. These booms carry small ploughs, or turning shares, and brushes which slide upon the floor and keep the beans in motion, thus allowing them to dry rapidly in the passing hot air. The upper part of the shaft drives a small exhaust fan which carries off all moisture as soon as formed.

This apparatus dries twelve to fifteen bags of cacao in thirty to thirty-six hours; the cacao being well prepared, the frequent movement of the beans polishing their exterior by the rubbing they get from contact with each other, thus taking the place of the "dancing" practised on sun-drying floors. The machine is driven by a small steam-engine, which is used for distilling "lime oil" when not working on cacao. At the estate where this dryer is in use cacao is fermented in cylindrical drums which are turned at stated intervals, on which those made by Marcus Mason and Co. are a great improvement.

Drying by solar heat, or sun drying.—The ordinary method of drying cacao is by means of the heat of the sun striking upon *wooden* floors. The mention of wooden floors needs accentuation, as in coffee-growing countries an attempt is often made to dry cacao on the "barbecues"

or cement floors used in drying coffee. Cacao so dried is never of the same ultimate quality as when dried upon a wooden floor. In the same way coffee dried upon a wooden floor can never equal similar raw material dried on a cemented floor or platform. The reason is that coffee submits readily to an amount of heat which would certainly spoil cacao, and *vice versâ*. In drying by the aid of sun alone, first-class work can be accomplished, if the weather is favourable; but if the weather is unfavourable for several days at a time, a very large amount of loss occurs, as it is impossible to prevent cacao passing into a bad condition when there is insufficient sun heat to stop the growth of the mould fungi which persistently attack it when in a wet or semi-dried state. It is this possible loss which the planter insures against when he invests in apparatus for drying without the aid of sun heat, and those not in possession of such appliances must be content to lose a large percentage of their crop in an unfavourable season, or if not lose it totally, to lose its value by some 30 to 40 per cent. of ruling prices.

Where a large extent of cacao is under cultivation, or, as one correspondent advises, where five hundred or more bags are produced per annum, it is clearly not economy to rely upon sun heat alone for the drying and curing of cacao.

For central factories the larger forms of dryer are an absolute necessity, and there can be little doubt that well-organised co-operative factories for drying and curing the produce of the cacao field would be a great boon to the smaller growers in all countries, and the produce exported from such countries would be much higher in value owing to uniformity in the method of drying and curing. The system of central factories has worked well with sugar-cane, coffee, coco-nuts, &c., and there appears no serious objection to its being utilised for the cacao interest, where conditions would admit of successful operation.

Up to the present time in Trinidad, however, with an annual crop of 50,000,000 lb. of cacao, the greater portion

is sun-dried by apparatus of various forms, the most common being the level wooden floor with movable roof, as depicted in Fig. 52. In this illustration labourers are seen cleaning cacao at A, and heaping it for "dancing" at B. In Grenada, drying houses are constructed with tiers of trays running on rails, which can be exposed or run under a fixed roof with greatest ease. Settlers and small growers are mostly content with large flat trays with a handle at each corner. These can readily be piled, one upon another under cover, at the approach of rain.

The detail of the general work of a sun-drying floor on a large estate is here given, that our readers abroad may be able to follow the principles upon which curing depends under Trinidad conditions.

General work on the drying floor.—(1) The first thing the operator has to attend to when starting to dry a batch of cacao is to see that his floors are well dry, *i.e.* not dry only on the surface, but that the boards have no internal moisture. The floors should be exposed to hot sun for some days before wet cacao is placed on them to be dried.

(2) On removing wet cacao from the "sweat boxes" and placing it upon the drying floor, opportunity is taken to get the picking or cleaning of the cacao completed as soon as possible, by assembling all available hands for this purpose. Cleaning consists in removing all diseased or immature beans, the removal of the placentas to which the beans are attached when inside the pod, and the removal of pieces of pods or other refuse they may have gathered in transit from the field. The operation being completed, the cacao is then left in the hands of the regular drying staff.

(3) The drying hands now cover the floor with a layer of the wet beans between three and four inches deep, this thickness being necessary in dry weather to prevent the beans drying too rapidly at first; in wet weather a thinner layer is used, in order to take every advantage to get the produce cured, but cacao is of better quality when slowly dried. The duties of the drying staff during the first two

FIG. 52. A SUN-DRYING CACAO FLOOR

FIG. 53.—"DANCING" CACAO IN TRINIDAD

days is to turn the cacao lying upon the floor evenly and frequently, so that all the beans may have the same amount of exposure. This is effected by the men walking "bare-footed" in straight lines from end to end, using their feet alternately to throw the cacao into small ridges between their two feet, each man taking half of the previously made ridge, right and left, to form the new ridge he leaves. When this operation is well done (workmen get very clever at it) it is very effective, and every bean gets an equal amount of exposure. Perfect cleanliness is maintained by managers, and the feet of the men are frequently washed. There is, however, no contact whatever between the part of the bean consumed and the feet of the labourers, as the whole skin of the bean comes off in the roasting process which it undergoes previous to being made into any of the forms to which manufacturers devote it.

(4) The operation just described leaves the floor between each ridge exposed to the sun, which allows it to dry, as well as the cacao in the ridge, and if the workman alternately exposes the surface the whole floor is maintained in a dry state, which assists in the dispersion of the moisture of the bean. If the beans were not continuously moved the floors would soak up a large proportion of the exudations from the beans, and the drying operation would not proceed on correct lines. In fact, the method pursued at this stage will materially affect the quality of the bean. As the operations proceed the cacao is made into small heaps at intervals of two or three hours in order to keep the floor space dry, and good operators (carefully watching the weather) will secure great advantage over the negligent, and often save cacao, where the latter would allow it to spoil. If the floors are not allowed to dry, mildew (mould fungus) is sure to make its appearance, although the cacao may be repeatedly turned. This treatment should be continued until the natural mucilage clinging to the skin of the bean is seen to be hardening somewhat and becoming pasty or sticky.

(5) At this stage comes the operation commonly known

on Trinidad estates as "dancing" (Figs. 52 and 53). The success of it depends very largely upon the experience of the leaders of the staff in judging when the cacao is fit for the process. If it is done too early the mucilage becomes lumpy, and cannot be evenly spread over the skin of the bean; some places will be too bare, and others will be covered too thickly. It is at this stage that clay is applied, as it readily unites with the mucilage on the bean. Whether the clay is or is not used, the operation is as follows. The cacao is shovelled together into heaps of some two barrels,* each at suitable distances from each other, and workmen of light build are chosen for dancing, who should not weigh more than 112 lb. to 130 lb. These men tread or dance on the top of the heap barefooted, as before, while women and children sitting round the base throw up the beans as fast as they are thrown down by the dancer. The latter operatives are also again on the look-out for damaged beans or foreign material, which they collect and remove. As the operation proceeds the appearance of the beans must be carefully watched, until they are seen to assume a surface to be likened unto that of a piece of polished Spanish mahogany. When this appears the heap should be opened out and the drying allowed to proceed as rapidly as possible. The following day the heaps should be again danced, opened out thinly upon the floors, and allowed to receive four or five hours of continuous sun heat, which will, by rapidly drying the interior and exterior, tend to fix the polish upon the skin of the bean.

It is at this stage that the services of a rotary dryer are especially useful, as unless quickly dried the polish will suffer and its fine colour will fade. The drying should be continued until by examination of a number of sections of the beans from different parts of the floor it is found that it is fit for the market. The time of treatment on the drying floor depends entirely upon the weather. Sometimes four to five days will suffice; in bad weather twice or thrice that amount of time.

* The barrel equals the American flour-barrel, which contains 196 lb. flour.

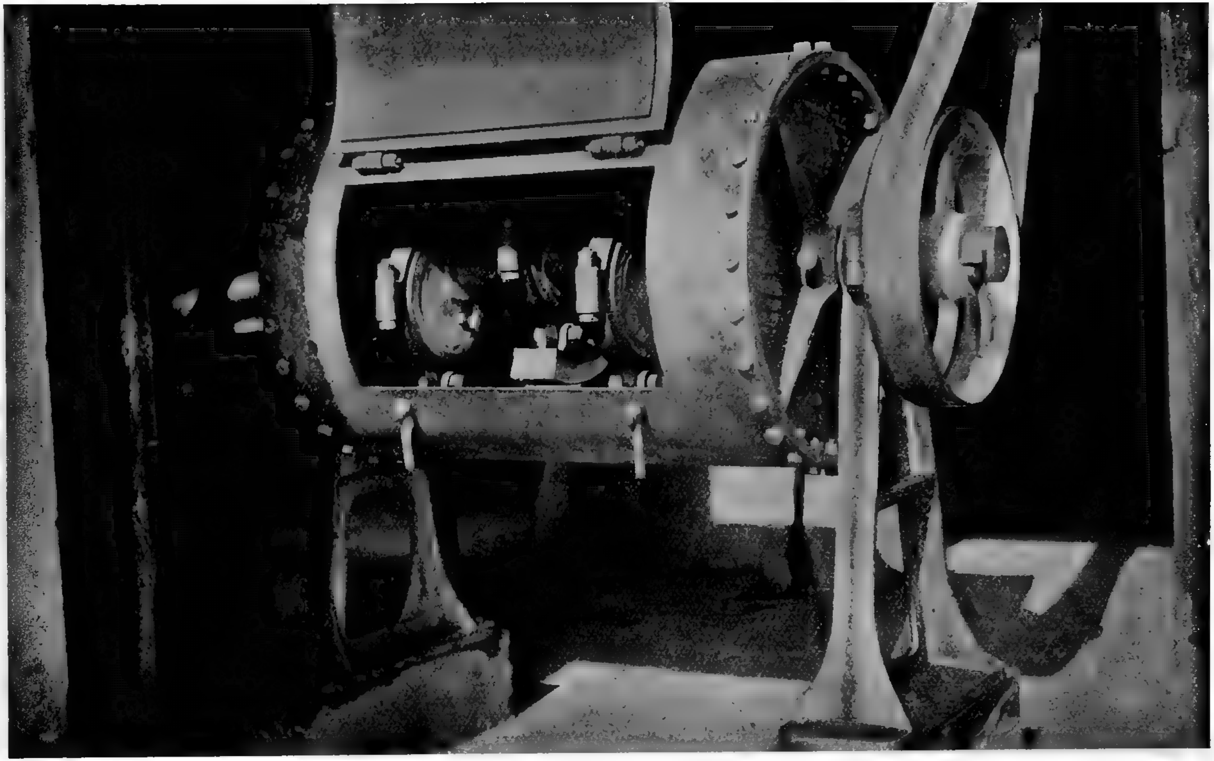

Fig. 54. Barnard's Patent Cacao Polisher

The object of the "dancing" and "polishing" is to seal up as far as practicable all possible cracks or orifices, &c., leading to the interior of the bean, in order to exclude the spores or germs of fungi; it is used frequently in bad weather to destroy or hinder development of the growth of fungi on the exterior of the bean, and it strengthens the shell or rind of the bean, and preserves it from cracking during transit to market. In some countries I am fully aware this is considered a "dirty process," and washing is preferred. Trinidad planters find that it pays, and as they do no washing they may be regarded by some as dirty. *N'importe*, the money comes in!

By the courtesy of the inventors the author is able to give a brief description of two inventions for polishing cacao, a process hitherto generally performed by hand, as described on the preceding page.

Barnard's patent cacao polisher, of which Fig. 54, facing page 172, is an illustration, consists of a cylinder made of wood or iron. A shaft is adapted to pass through the hollow trunnions. One trunnion is provided with a driving pulley, whilst the shaft is provided with another pulley, and they are driven in opposite directions and at different speeds. The shaft is fitted with a number of eccentrics, to which heavily weighted jointed rubber feet or pedals are attached, to give a rocking motion as the eccentrics rise and fall, so as not to bruise the beans. The pedals do not come within 2 in. of the cylinder or casing, and are spaced sufficiently far apart to allow the cacao to stir about freely. The cylinder is driven at the rate of ten revolutions per minute, and the shaft at sixty to eighty. At this rate a machine in operation (a four-pedal machine) polishes 250 lb. of cacao in ten to twelve minutes. Smaller machines of the same type to be driven by hand-gear and worked by one man have been arranged for by the patentees.

The "Malins-Smith" cacao-polishing machine, depicted by Fig. 55 on page 175, consists of a rotary cylinder containing a series of agitating rods which are placed

longitudinally. The rods are fitted at one end, on the outside of the cylinder, with pinion wheels which work on a centre spur wheel attached to the axle shaft of the cylinder. The inside of the cylinder is smooth and so is the surface of the agitating rods, the cross-sectional shape of which is elliptical. The cylinder revolves at fifteen and the agitating rods at 360 revolutions a minute, and has a convenient aperture for filling and emptying. The machine is made in sizes to contain one and a half, three, and five bags of cacao, or 270 lb., 540 lb., and 900 lb. respectively. Gearing is attached to the machine for driving the smallest size by hand-power and the two larger sizes by engine-power. A $2\frac{1}{4}$ horse-power oil-engine will drive the largest size. The cacao beans are polished in ten minutes by the machine, and with conveniences and quick despatch four lots can be polished in one hour. The cacao beans must be slightly wetted with plain water before being put into the machine, and the cylinder should be only three-quarters to seven-eighths filled. The advantages claimed for this machine are manifold, and include besides the saving in cost of polishing, saving in time, in worry, and in labour. No beans are crushed by the machine, and the beans are turned out fuller in shape than by any other process.

Size of floor required.—Drying-houses are generally built of wood in Trinidad, but progressive planters are now building the framework with *Ferro,* or reinforced concrete frames; in any case, always with wooden drying floors. Sometimes they are raised 6 ft., 8 ft., and 10 ft. above the ground level, the ground floor being sometimes utilised for "sweat-boxes," store-rooms, offices, &c. This is, however, undesirable, as cacao is easily contaminated.

Sun-drying floors are sometimes built with solid walls, allowing a chamber below into which heating apparatus of various kinds are adjusted, from the antiquated flue, to pipes containing low-pressure steam, so as to enable the planter to dry at will, either by sun or by artificial heat

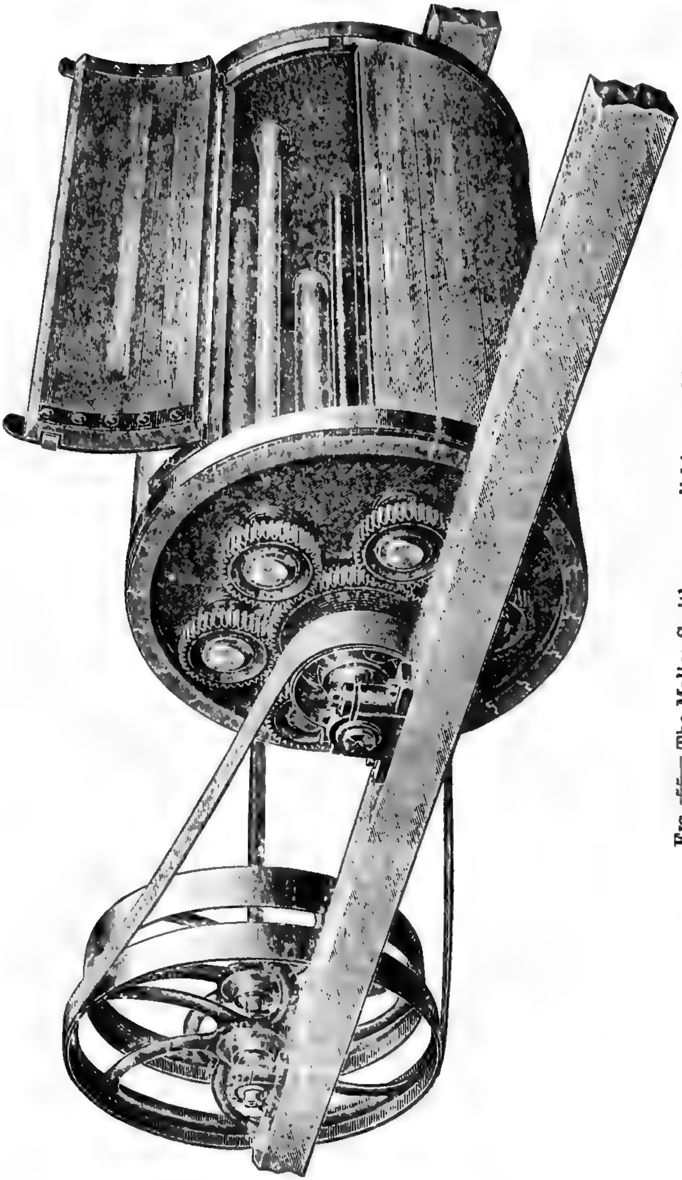

FIG. 55.—The Malins-Smith cacao-polishing machine.

in bad weather. Such combinations are, however, not in great favour, and not one drying house in a hundred is as yet supplied with artificial heat.

The capacity of floors for drying purposes may be estimated at eighty square feet of floor surface to every thousand trees, but less on larger estates. One thousand trees may be taken as affording an annual crop of ten to fifteen bags of cacao of 165 lb. each, the crop varying in accordance with the condition of the trees, cultivation afforded, and fertility of the soil. The loss of weight during the fermentation and curing process has been already discussed in previous pages. Wright, in his work, shows that our figures agree generally with the results obtained on Ceylon estates.

Merchants' drying floors.—These floors are maintained near to warehouses at the place of shipment. In all respects they are similarly constructed to those in use by planters. They are used for finishing samples brought in imperfectly cured, and for mixing and equalising or grading lots brought into the local market by small growers, in which there is a considerable trade, it being estimated that at least one-third of the exported cacao of Trinidad is produced by them. Numbers of estates also sell in the local market and the practice is increasing, but many large and well-known estates still continue to ship on their own account under standard marks.

On the merchants' floors the several purchases are graded into their various classes to suit the market under distinctive names such as "Fine Estates," "Good Ordinary," "Good Fair," "Middling," &c. &c., and many others.

In some establishments a considerable amount of artificial colouring is given to the exterior of the beans, but as cacao is seldom purchased, except under close examination of the character of the interior of the beans, it does not seriously affect prices, although it is maintained that a manipulated sample of even colour will bring slightly higher prices than a sample clearly showing its mixed character at sight.

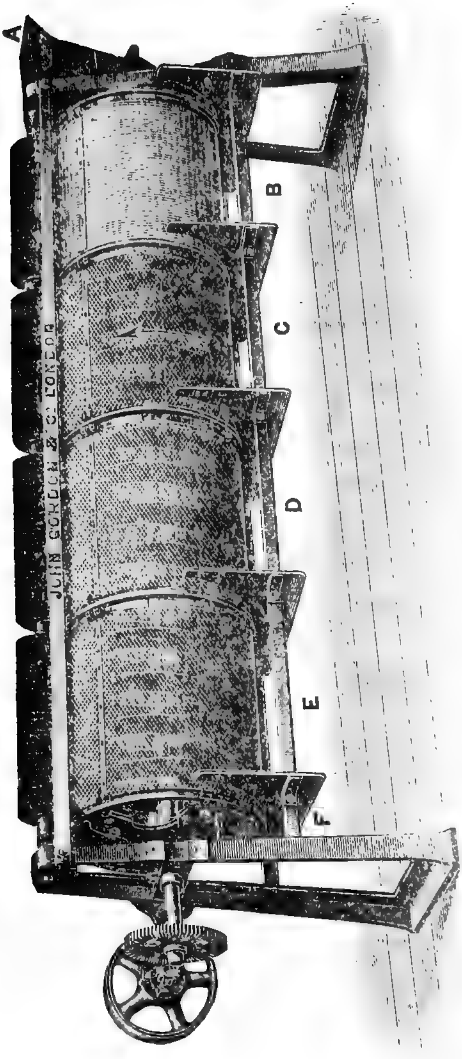

Fig. 56.—A cacao-grading machine.

Grading for size is practised to a considerable extent on large estates, and also on merchants' floors. It is done chiefly by means of wire cylinders working in a sloping

direction, having meshes calculated to allow the escape of the various sizes of beans and waste material that is required to be removed from the best samples. The apparatus is shown in Fig. 56. It consists of a cylinder covered with removable perforated plates. The interior of the cylinder is furnished with a worm which gently moves the cacao beans along the cylinder, thus ensuring even and perfect grading. The machine can be built with any number of divisions, so as to grade as may be desired. The produce is inserted at A, and delivered under five separate classifications. At B, grit, dirt, &c., or *Passe*; at C, thin flat beans; at D, small-sized beans; at E, medium-sized beans; and at F, large-sized beans; all of which have their different markets, the ultimate destination of the very lowest qualities being often somewhat of a mystery to the grower.

Coco-nut matting is never used in Trinidad for drying cacao.

CHAPTER XVI

AGRICULTURAL CHEMISTRY OF CACAO

A few years ago Professor J. B. Harrison, C.M.G., the Director of Science and Agriculture in British Guiana, furnished a chapter on the agricultural chemistry of cacao for the second edition of "Cacao," by the author. On recent reference he informed the writer that at present he had nothing new to add to what he had previously written, with the exception of one or two minor criticisms, which he did not admit to have any bearing. Professor Harrison's work has not been questioned, and it still remains as a standard record with regard to the chemical contents of the produce of the cacao-tree, and the characters of the soil on which it grows.

That further advances in our knowledge of the chemistry of cacao, and questions connected therewith is desirable, and will appear in due time, there can be no question; and as shown in the Professor's concluding paragraph, such work is confidently anticipated when he says that "Work already done in this line is fully compensated for if it leads others more favourably situated to take up the study of this interesting and intricate subject."

The direction which some further inquiries will take will probably be a careful examination of the methods of fermentation, the changes that take place during that process, what causes them, &c. &c. In fact, a project for obtaining further information has been formulated and prizes offered for the best essay on this subject. Personally the writer is of the opinion that what is to be gained in this direction will be vastly insignificant in comparison with that to be gained in other directions, but of course

there are other opinions the examination of which may also lead to progress in our methods.

Of the soundness of the work carried out by Professor Harrison there can be no possible doubt, as it has already stood the test of criticism for a number of years and is quoted by the best writers and authorities.

Wright, in his latest work, has also given to the public some twelve pages of valuable matter on the chemistry of cacao, in which various analyses are quoted, to which reference might be profitably made by inquirers. At pages 161, 162, under the heading of chemical tests for varieties of cacao, he has the following:

> A considerable amount of work has been done by Trojanowsky and Jumelle to determine whether different cacaos can be identified by means of chemical tests. The kernels of different varieties were powdered, and mixed with a definite proportion of sugar and distilled water, and after filtering the filtrate was divided into many portions and each treated with a specific reagent. The colour of the precipitate, if any appeared, and that of the solution were considered to indicate the variety of cacao under examination; by means of solutions of nitrate of copper, nitric acid, nitrate of silver, chloride of zinc, chloride of mercury, and other reagents it was hoped to distinguish between Caracas, Surinam, Trinidad, Guayaquil, Ariba, and other cacaos, according to the colour, reactions, and nature of the precipitates produced. In some cases the tests appeared to be useful, but in most instances they could not be recommended as reliable.

This is a result which might reasonably have been looked for, and is valuable as a proof of the negative; for the range of variation in cultivated varieties of cacao is so wide as to lead to the conclusion that results obtained by the examination of samples could only be proportionately valuable in so far as they showed agreement in the major factors of their contents, and in that way suggesting, but not proving, affinity. It is taken for granted by some that the names given to varieties of cacao actually show permanence in varieties, which position is untenable.

On the other hand, however, the analysis of two selected varieties, after Harrison's method, if taken from single standard trees, would show differences which would not only be permanent and reliable tests for detecting any special variety, but would give very indefinite results when used on specimens from seedling trees, each and every

one different from the other, though bearing a family likeness to certain types.

The writer does not quite follow Wright when he states that:

> Experience on an estate where cacao is grown will convince *any one* (italics, the writer's) that the chemical constituents of the same variety of cacao are liable to a considerable amount of variation, according to the nature of the soil, the age of the trees, and their condition of vigour. In any one country where cacao has been long cultivated, different seeds in the same fruit from a Caracas, Nicaraguan, or Forastero tree will vary to an extent which is often surprising.

That they do vary in the way described is an undoubted fact, but the present writer attributes the cause more to the interbreeding of cultivated varieties, than to influence of soil, age, or cultivation.

Wright also says:

> The cacao exported from any district is composed of seeds of innumerable varieties, and although that from each country may tend to become more or less uniform year by year, *the variations during a single year or in successive years* (italics, the writer's) must be sufficiently great as to seriously affect the value of a chemical test as a means of determining the actual variety or country of export.

With respect to the last quotation, the author may say that he has failed to observe any material change in the produce of single trees from year to year, but can fully confirm the statement that "cacao exported from any district is composed of seeds of innumerable varieties." It could not possibly be otherwise, all being seedling varieties, and it certainly represents the conditions present in all the cacao-growing countries which the writer has personally visited.

The fact is, the number of varieties which exist would keep *all the chemists now living, and as many more,* fully employed for life, to test every variety of cacao now grown, and this alone proves the absolute uselessness of the attempt, and shows that, until standard varieties of the best types are secured by selection methods, the analysis of the cacao bean is not likely to show greater results than are already shown by Harrison's work, a point with which the writer has reason to believe Professor Harrison is in full accord.

At the present time the manufacturers probably know

more about the chemical contents of the cacao bean than either planters or consumers, although they have not been particularly anxious, for business reasons, to publish their results. That they possess this knowledge is shown by the admirable way in which they grade the material they buy for producing any quality or kind demanded by the public; the difference in the various qualities (including flavour, colour, and aroma) being maintained at fixed standards year by year.

Wright continues with a paragraph stating:

That it is hard enough to identify all the varieties on an estate, even when leaves, flowers, fruit, and seeds are at hand, and it must be much more difficult to determine constant chemical characteristics for the ever-changing forms of cacao under cultivation.

The writer assumes that he does not mean that the changes occur in individual trees year by year, but that in planting new seedling forms the variation is increasing annually. With the latter the writer concurs, but with the former he cannot agree, as under his extended observations a seedling, once established, never changes but remains the same in all respects as an animal born into the world, and suffers similar trials as an animal would have to pass, until its life is ended; and also dies an individual with special characters of its own, permanently and practically unalterable, though showing plainly a family likeness to its progenitors of several previous generations. "Sporting" * in cacao is the exception, not the rule, and in our experience does not frequently occur.

Great variation is now generally admitted to take place among cultivated cacao. The Forastero of one place is not the exact Forastero of another, owing to its coming into contact with differing strains and apparently interbreeding with them. Where strains of fine quality have been introduced, these have in some cases produced seedlings of improved character and, among these, in fact among all the various strains, cacao-trees of high quality may be found capable and worthy of becoming selected

* "Sporting" is a deviation from the type which may occur in a single branch.

varieties and cultivated as such for the various markets, in fact the plant breeder should be able to make or raise forms having qualities of the highest excellence and of varying flavours, aroma, and strength.

Until such standards * are established, the analyses of various kinds do not appear to offer progressive results, as it is certain that no two analyses could possibly agree, and cannot have that desirable exactness which generally characterises chemical work.

If, however, standard kinds were selected, planted and grown, it would be quite easy to establish analytical standards for each particular quality, but so long as only seedling and variable kinds are cultivated, there appears to be little use for analysis; and sight value, or buyer's examination, would probably be as accurate as the best chemical examination.

It has been shown in a previous chapter that the action of fermentation is of less relative value than is the primary quality of the bean which is being fermented, and it surely would be better to direct attention to the point of securing that primary quality instead of endeavouring to secure results from inferior material by the fermentation treatment.

If the operator can start with a bean of high and even quality it would clearly be more to his advantage to use it, than to use the produce of mixed seedlings, and have to work up the latter by treatment to better form. Yet this is what is being done every day on the greater number of cacao estates, and the skill of the chemist is being invoked to devise methods of improvement in the fermentation process of inferior kinds, while we know that the better class of produce readily admits of much simpler treatment to fit it for the market.

Chemical examination, full and complete, should, however, be made of all kinds selected as standards, in

* A standard kind can be defined as the best individual kind that can be selected from various known strains, each selection representing a particular kind or quality, and chosen for vigour, productiveness, or other desirable quality.

order to inform the planter as to the direction the selection of new varieties should take in order to be able to obtain those most suited to the manufacturer.

Until a selection of standard kinds has been completed little can be done by aid of chemical research more than has been already published by Professor Harrison, for reasons well stated by Wright in his chapter on the Chemistry of Cacao, with which for the major part the writer concurs.

Further chemical work on the innumerable varieties as they now stand would, the writer assumes, merely make "confusion worse confounded." A reference to Wright's and Jumelle's works shows fairly well what has already been done, but, as previously pointed out, every analysis has been done on mixed seedling varieties of various strains, which must, *per se*, be of much less value than those made on standard varieties.

Professor Harrison's analyses were made on cacao of the usual description of Forastero and Calabacillo strains, and his work may well be used as the best information obtainable on the two classes examined, taken as classes; but it cannot be doubted that, if single selected trees are examined, different and far more interesting and profitable results would become apparent. Meanwhile, Harrison's Tables are the fullest yet available on West Indian produce, the Forastero variety may be looked upon as a good mean between the highest and lowest classes of West Indian cacao, and the analyses are therefore again included in full.

It is public knowledge that the husks or skins of the bean are put to economic use, but reference to previous notes on the treatment of cacao in curing shows that in treatment the skin is covered with extraneous matter which would preclude its being manufactured into anything but the lowest class of material. As, however, the skin or husk is only used after complete roasting, during which most of the external matter disappears as dust, objection to its use is somewhat minimised.

The principal constituents of the cacao bean are: (1) alkaloids; (2) starch and sugars; (3) albuminous matters; and (4) cacao butter, together with various mineral substances.

Wright describes the first-named as highly compact organic compounds which are responsible for the stimulating effect of cacao. Harrison makes return of having found a variable percentage of theobromine, and that caffeine occurs in much smaller amounts, as shown by his Tables. Starch and sugar were found in Forastero to following amounts (*see* Table XII. p. 203, Harrison):

Starch in dried bean	9·043	per cent.
,, ,, cured ,,	6·750	,,
Sugar (glucose) in dried bean	·257	,,
,, ,, ,, cured ,,	·556	,,
,, (sucrose) ,, dried ,,	1·373	,,
,, ,, ,, cured ,,	Nil.	

Albuminoids and indeterminate nitrogenous matters are represented in the dried material of Forastero 11·2 per cent., and in the cured material at 8·6 per cent., and fatty matters show at 45·8 per cent. in the dried to 52·1 per cent. in the cured material, the mineral substances being particularly rich in phosphoric acid, potash, and magnesia. The colouring-matter is determined as "cacao red," which, with theobromine, is said to give to cacao its characteristic taste.

Harrison on Agricultural Chemistry of Cacao.

The composition of the different parts of the cacao-tree has been treated upon by Marcano of Venezuela * and in part by Boname, late of Guadeloupe, now of Mauritius.† Opportunities for studying the requirements of the plant as represented by the composition of the mature trees themselves being very limited, we accept for guidance the

* "Essais d'Agronomie Tropicale." V. Marcano.

† "La culture de la canne à sucre à la Guadeloupe." Pf. Boname.

result given by Marcano. This authority estimates that a cacao-tree twenty years old is made up of :

Trunk	49·5
Large branches	21·1
Medium branches	11·0
Small shoots	12·0
Leaves	6·4
	100·0

and that a plantation of trees of this age growing on one acre will contain :

Nitrogen	201 lb.
Phosphoric anhydride	95 ,,
Potash	251 ,,
Lime	400 ,,
Magnesia	111 ,,

whilst the so-called suckers and other young shoots trimmed annually from the trees contain : *

Nitrogen	84 lb.
Phosphoric anhydride	49 ,,
Potash	42 ,,
Lime	66 ,,
Magnesia	20 ,,

These, together with the leaves, which he states contain :

Nitrogen	39 lb.
Phosphoric anhydride	75 ,,
Potash	30 ,,
Lime	32 ,,
Magnesia	10 ,,

are practically in all cases yearly returned to the soil.

The fruit, of which the husks may or may not be returned to the soil, according to whether the pods are or are not broken on the field, are estimated to remove as follows :

	If whole fruit removed from the field.	If the pods are broken and left in the field.
Nitrogen	15·5	8·7 lb.
Phosphoric anhydride	7·9	4·5 ,,
Potash	22·1	3·7 ,,
Lime	6·5	1·4 ,,
Magnesia	2·3	1·0 ,,

From these figures it appears that the cacao-tree, whilst storing up in the plant itself relatively large proportions

* This latter estimate appears to the author to be excessive.

of the important elements of plant food present in the soil, requires for the yearly production of young shoots, leaves, and fruit not less than 138 lb. of nitrogen, 64 lb. of phosphoric anhydride, 94 lb. of potash, 104 lb. of lime, and 31 lb. of magnesia per acre. Under careful conditions of agricultural practice, however, of this great annual drain upon the soil, but 8·7 lb. of nitrogen, 4·5 of phosphoric anhydride, 3·7 lb. of potash, 1·4 lb. of lime, and 1 lb. of magnesia are necessarily removed from it, the remainder becoming more or less available again for plant food by the decomposition of the fallen leaves, pruning, and husks upon the land. Of the (in round numbers) 130 lb. of nitrogen returned to the soil a considerable proportion, possibly 20 to 30 per cent. may be lost during the decomposition of the vegetable matter, but where the trees are shaded by the nitrogen-collecting bois immortel or oronoque trees (*Erythina velutina* and *E. umbrosa* which are used on the islands, or *E. glauca* which is used in Guiana) doubtless much of the amount thus lost is recouped to the soil.

These considerations lead to the conclusion that a good cacao soil should be one capable of yielding to the tree in the course of years a somewhat high proportion of the important constituents of plant food without exhaustion, and also capable of rapidly rendering again available the large quantities of manurial matter returned to it in the forms of prunings, leaves, fallen and broken pods. It must, in addition, be one in which the course of nitrification readily takes place; in other words, a fairly rich friable and well-drained soil is of prime importance for the successful production of cacao.

The samples from Grenada, St. Vincent, and Demerara were personally selected, while those from Trinidad and Nicaragua were given to us and described as very fertile cacao soils by J. H. Hart, Esq., F.L.S. With the exception of the Surinam, Demerara, and Trinidad samples, all are of soils arising from the degradation of lavas and volcanic *débris*, rich in soda lime felspars. As a rule, these fertile cacao soils are fairly rich in nitrogen, and contain a

TYPES OF GOOD CACAO SOILS RECENTLY EXAMINED IN THE GOVERNMENT LABORATORY, BRITISH GUIANA

	Demerara.	Grenada.				St. Vincent.	Trinidad.	Nicaragua.	Surinam.	
		No. 1.	No. 2.	No. 3.	No. 4.				No. 1.	
(1) Organic matters and combined water	9·031	7·644	10·442	10·993	9·688	3·046	3·768	10·815	15·452	10·810
Phosphoric anhydride	·087	·082	·184	·044	·058	·114	·084	·293	·139	·109
Sulphuric anhydride	·018	·118	traces	traces	·027	·055	traces	·141	·047	·358
Chlorine	traces	traces	nil	traces	traces	traces	nil	·007	trace	trace
Iron peroxide	4·783	9·085	9·485	18·672	12·033	9·574	3·910	7·000	5·952	7·567
Alumina	9·217	13·628	10·024	17·140	12·710	8·889	2·038	4·717	16·076	14·668
Manganese oxide	·347	·191	·313	·379	·249	·435	·127	·163	nil	·108
Calcium oxide	·596	1·335	2·379	·481	1·183	4·981	·356	2·250	·495	·408
Calcium carbonate	·032	·236	·026	·185	·099	nil	nil	nil	nil	nil
Magnesium oxide	·404	1·367	3·367	1·261	·680	2·418	·495	·217	1·071	1·547
Potassium oxide	·291	·254	·343	·169	·428	·178	·118	·619	1·072	1·042
Sodium oxide	·208	·393	·574	·197	1·102	·369	·278	1·184	·258	·271
Insoluble silica and silicates	74·986	65·667	62·863	50·509	61·743	69·941	88·826	72·594	59·438	63·112
	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000
(1) Containing nitrogen	·262	·309	·271	·286	·224	·205	·100	·228	·306	·272
Water retained by air-dried soil	6·5	8·5	12·4	14·3	9·6	8·1	1·8	8·0	11·	7·5

EXAMPLES OF POOR CACAO SOILS UPON WHICH THE YIELDS ARE VERY UNSATISFACTORY

	Demerara.					Grenada.		
	No. 1.	No. 2.	No. 3.	Surinam.	St. Vincent.	No. 1.	No. 2.	No. 3.
Organic matters and combined water	2·786	4·471	1·921	18·701	3·029	14·540	8·035	12·897
Phosphoric anhydride	·021	·020	·002	·157	·042	·024	·120	·050
Sulphuric anhydride	·017	·111	nil	nil	·045	·037	·028	·099
Chlorine	trace	nil	nil	trace	trace	trace	traces	trace
Iron peroxide	2·231	4·081	·992	3·874	9·695	14·300	9·642	22·349
Alumina	3·353	7·214	1·834	15·269	7·374	11·808	15·403	26·925
Manganese peroxide	·008	·005	·250	nil	·487	·109	·084	·320
Calcium oxide	trace	·225	·017	·010	4·787	·534	·196	·210
Calcium carbonate	nil	nil	nil	nil	trace	trace	·152	·264
Magnesium oxide	·423	·041	·072	·661	1·899	·422	·160	·314
Potassium oxide	·109	·051	·029	·041	·083	·041	·097	·056
Sodium oxide	·100	·225	·037	·003	·704	·398	·360	·230
Insoluble silica and silicates	90·952	83·556	94·846	61·284	71·855	58·387	65·723	36·286
	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000
(1) Containing nitrogen.	·077	·057	·063	·265	·075	·137	·109	·171
Water retained by air-dried soil	1·3	1·9	·4	7·6	7·6	8·2	10·4	14·1

somewhat high amount of potash, of which a relatively high proportion was found to be soluble in 1 per cent. citric acid solution, whilst the proportion of phosphoric anhydride present appears to be of lesser importance. They can, we consider, be safely regarded as reliable types of the composition of really fertile cacao soils.

As far as present experience goes in the selection of good reliable soils for cacao cultivation, if the physical conditions are in accordance with those mentioned in a previous paragraph, the most important point chemically is that the soil should contain an ample supply of available potash, a fair supply of nitrogen, and a medium one of phosphoric anhydride and of lime, and should have either from its chemical composition or its physical condition a marked retentive power for hygroscopic moisture. On soils of this kind large and remunerative crops of cacao may reasonably be expected even in seasons during which on other lands crops may suffer from drought.

In order to obtain reliable data as to the composition of cacao grown under fairly favourable conditions at low elevations, Charles Ross, Esq., of Pln. Land of Canaan, Demerara River, supplied us with a large number of freshly gathered ripe pods of cacao of two varieties: first, the small-podded, thick, smooth-skinned variety with flat beans known as Calabacillo; and secondly, the large-podded, somewhat thick, rough-skinned variety with full rounded beans, known as Forastero. The former is the variety agriculturally best suited for heavy lands, being the hardiest of all varieties, and giving on low-lying land by far heavier yields of cured cacao than Forastero does. In addition we obtained from him cured beans of these varieties. Many other varieties are to be found growing in greater or less abundance in the cacao groves of British Guiana including the Criollo or Caracas kind, but as the bulk of the crop appear to consist of Forastero and Calabacillo cacao, principally of the former, attention was confined to them.*

* Harrison's reason for selection of the two kinds.

The fresh pods were found to yield as follows :

	Calabacillo		Forastero.
Husk	80·59	..	89·87
Pulp	7·61	..	4·23
Cuticles of beans	1·77	..	·50
Kernels of beans	10·03	..	5·40
	100·00	..	100·00

The yields of cured cacao are 37·5 and 35·6 per cent. of the beans and pulp of the two varieties respectively. Hence 100 lb. of the fruit of Calabacillo will yield 7·25 lb. of fermented cured cacao and 100 lb. of the fruit of Forastero 3·6 lb. There would appear to be a distinct advantage in growing cacao of the variety Calabacillo ; but the difference in the market value of the small flat brands of this variety and in that of the large plump beans of Forastero very materially reduces the apparent advantage, while comparatively upon light soils of higher elevation the agricultural yield of Calabacillo is frequently less than that of Forastero.

The fresh fruits were rapidly divided up into the outer husks, the cuticles of the beans and their adherent pulp, and the inner kernels of the beans or cocoa nibs proper. The cured beans were also divided into cuticles and inner kernels. After weighing, all parts of the fresh fruit were dried at a temperature of about 140° F. until they ceased to lose weight, the loss of moisture noted, and the dry material carefully ground up and sampled.

Analyses were afterwards made of these portions, and the results calculated back to the original state of the fruits as received.

The following show the detailed composition of the fresh fruits of each variety, of the various parts of the fruits, and the distribution of the constituents in the parts of the fruit :

TABLE I

WHOLE FRUIT OF CACAO, VARIETY "CALABACILLO"

Water	78·790
(1) Albuminoids	1·470
(2) Theobromine	·234
(3) Caffeine	·015
(4) Indeterminate nitrogenous matters	·067
Fat	3·093
Glucose	·274

Sucrose	·006
Starch	·844
Astringent matters	2·332
Pectin, &c.	5·221
Cacao-red	·888
Digestible fibre	5·405
Woody fibre	3·122
Tartaric acid, free	·324
Acetic acid, free	·054
Tartaric acid, combined	·716
Iron peroxide	·008
Magnesia	·120
Lime	·042
Potash	·468
Soda	·038
Silica	·007
Sulphuric anhydride	·044
Phosphoric anhydride	·152
Chlorine	·032
	99·267
(1) Containing nitrogen	·212
(2) " "	·072
(3) " "	·004
(4) " "	·030
Total nitrogen	·325

TABLE II

CONSTITUENTS OF THE VARIOUS PARTS OF THE CACAO FRUIT, VARIETY "CALABACILLO"

	Kernels of beans.	Cuticles and pulp.	Husks.
Water	37·637	87·600	82·893
(1) Albuminoids	6·696	·918	·760
(2) Theobromine	1·352	·241	·094
(3) Caffeine	·108	·341	nil.
(4) Indeterminate nitrogenous matters	·531	traces.	·169
Fat	29·256	·444	·146
Glucose	·991	·725	·132
Sucrose	traces.	·066	traces.
Starch	3·764	·945	·469
Astringent matters and tannin	5·004	·395	2·225
Pectin, &c.	·657	·815	1·710
Cacao-red	2·952	·511	·675
Digestible fibre, &c.	5·112	4·652	5·411
Woody fibre	3·030	1·346	3·341
Tartaric acid, free	·079	439	·347
Acetic acid, free	nil.	nil.	·064
Tartaric acid, combined	477	·303	·796
Iron peroxide	·032	·004	·005
Magnesia	·324	·114	·099
Lime	·054	·054	.039
Potash	·142	·190	.454
Soda	·239	·041	.041
Silica	·016	·002	.006

	Kernels of Beans.	Cuticles and pulp.	Husks.
Sulphuric anhydride	·079	·021	·042
Phosphoric anhydride	·749	·115	·082
Chlorine	·019	·018	·036
	100.000	100.000	100.000
(1) Contains nitrogen	1·071	·147	·121
(2) ,, ,,	·416	·077	·029
(3) ,, ,,	·031	·012	nil.
(4) ,, ,,	·085	nil.	·027
Total nitrogen	1·603	·236	·177

TABLE III

DISTRIBUTION OF THE CONSTITUENTS OF THE FRESH CACAO FRUIT, VARIETY "CALABACILLO"

Per cent. of parts.	Kernels of Beans. 10·03	Cuticles and pulp. 9·38	Husks. 80·59
Water	3·7751	8·2169	66·7980
(1) Albuminoids	·6716	·0861	·6125
(2) Theobromine	·1355	·0226	·0757
(3) Caffeine	·0108	·0038	nil.
(4) Indeterminate nitrogenous matters	·0532	traces.	·0136
Fat	2·9343	·0413	·1177
Glucose	·0994	·0680	·1064
Sucrose	traces.	·0062	traces.
Starch	·3775	·0886	·3780
Astringent matters	·5019	·0370	1·7931
Pectin, &c.	·0659	·0764	1·3800
Cacao-red	·2961	·0479	·5438
Digestible fibre, &c.	·5127	·5316	4·3607
Woody fibre	·3039	·1262	2·6917
Tartaric acid, free	·0079	·0412	·2748
Acetic acid, free	nil.	nil.	·0543
Tartaric acid, combined	·0478	·0284	·6399
Iron peroxide	·0032	·0004	·0048
Magnesia	·0325	·0107	·0765
Lime	·0050	·0051	·0314
Potash	·0844	·0182	·3659
Soda	·0240	·0038	·0101
Silica	·0016	·0002	·0041
Sulphuric anhydride	·0080	·0020	·0338
Phosphoric anhydride	·0751	·0408	·0661
Chlorine	·0019	·0016	·0290
	10·0293	9·3750	80·4616
(1) Contains n trogen	·1074	·0138	·0975
(2) ,, ,,	·0417	·0072	·0233
(3) ,, ,,	0031	·0011	nil.
(4) ,, ,,	·0085	traces.	·0217
Total nitrogen	·1607	·0221	·1425

TABLE IV

Whole Fruit of Cacao, Variety "Forastero"

Water	81·877
(1) Albuminoids	1·234
(2) Theobromine	·152
(3) Caffeine	·015
(4) Indeterminate	·175
Fat	8·800
Glucose	·927
Sucrose	·054
Starch	·780
Astringent matters	·424
Pectin, &c.	1·022
Cacao-red	·684
Digestible fibre	4·097
Woody fibre	5·055
Tartaric acid, free	·255
Acetic acid, free	·053
Tartaric acid, combined	·564
Iron peroxide	·010
Magnesia	·119
Lime	·040
Potash	·368
Soda	·011
Silica	·008
Sulphuric anhydride	·033
Phosphoric anhydride	·147
Chlorine	·006
	99·910
(1) Containing nitrogen	·198
(2) ,, ,,	·046
(3) ,, ,,	·004
(4) Containing nitrogen	·028
Total nitrogen	·278

TABLE V

Constituents of the Various Parts of the Cacao Fruit, Variety "Forastero"

	Kernels of Beans.	Cuticles and pulp.	Husks.
Water	36·567	83·030	84·538
(1) A buminoids	4·826	1·271	1·017
(2) Indeterminate nitrogenous matters	2·752	nil.	·031
(3) Theobromine	·822	·348	·098
(4) Caffeine	·222	·059	nil.
Fat	30·602	·421	·142
Sucrose	·165	1·001	·969
Glucose	·917	· 091	nil.
Starch	6·038	1·305	·445

	Kernels of Beans.	Cuticles and pulp.	Husks.
Astringent matters	4·894	·108	·172
Pectin, &c.	1·380	1·126	·995
Cacao-red	1·543	·705	·631
Digestible fibre	2·821	6·564	4·045
Woody fibre	3·458	2·455	5·288
Tartaric acid, free	·038	·606	·250
Acetic acid, free	nil.	trace.	·059
Tartaric acid, combined	·487	·351	·580
Iron peroxide	·032	·010	·009
Magnesia	·454	·073	·101
Lime	·105	·030	·037
Potash	·635	·248	·358
Soda	·068	·015	·073
Silica	·016	·003	·008
Sulphuric anhydride	·048	·931	·032
Phosphoric anhydride	1·045	·098	·096
Chlorine	·032	·061	·026
	100·000	100·000	100·000
(1) Containing nitrogen	·772	·203	·163
(2) " "	·436	nil.	·005
(3) " "	·271	·107	·030
(4) " "	·064	·107	nil.
Total nitrogen	1·543	·327	·190

TABLE VI

DISTRIBUTION OF THE CONSTITUENTS OF THE FRESH CACAO FRUIT, VARIETY "FORASTERO"

	Kernels of Beans.	Cuticles and pulp.	Husks.
Per cent. of part	5·40	4·73	89·7
Water	1·9746	3·9273	75·9750
(1) Albuminoids	·2605	·0501	·9136
(2) Indeterminate nitrogenous matters	·1471	nil.	·0278
(3) Theobromine	·0476	·0164	·0880
(4) Caffeine	·0119	·0028	nil.
Fat	1·6524	·0199	1·276
Glucose	·0089	·0473	8·708
Sucrose	·0495	·0043	nil.
Starch	·3186	·0617	·3999
Astringent matters	·2643	·0051	·1546
Pectin, &c.	·0745	·0532	·8942
Cacao-red	·0833	·0333	·5671
Digestible fibre	·1519	·3105	3·6352
Woody fibre	·1867	·1161	4·7522
Tartaric acid, free	·0020	·0286	·2246
Acetic acid, free	nil.	trace.	·0530
Tartaric acid, combined	·0263	·0166	·5213
Iron peroxide	·0007	·0005	·0081
Magnesia	·0245	·0034	·0907
Lime	·0056	·0014	·0332

	Kernels of Beans.	Cuticles and pulp.	Husks.
Potash	·0343	·0117	·3217
Soda	·0036	·0007	·0065
Silica	·0008	·0002	·0072
Sulphuric anhydride	·0026	·0015	·0288
Phosphoric anhydride	·0564	·0046	·0864
Chlorine	·0016	·0024	·0023
	5·3912	4·7296	89·7898
(1) Containing nitrogen	·0417	·0096	·1465
(2) " "	·0233	nil.	·0045
(3) " "	·0146	·0050	·0270
(4) " "	·0232	·0008	nil.
Total Nitrogen	·0830	·0154	·1780

The fruit of Calabacillo contained less water but distinctly more nitrogen, potash, and phosphoric anhydride than that of Forastero. The kernels of the beans of Calabacillo were distinctly richer in the alkaloids, also in astringent matter and in cacao-red than were those of Forastero, the result being that the beans of the former variety were of a harsher, more astringent flavour than those of the latter. The beans of the two varieties showed but little difference in their contents of fat, but those of Forastero were of higher contents of starch and sugars. In the cuticles and pulp from Calabacillo there were found somewhat lesser amounts both of the alkaloids and of starch and sugars than in those from Forastero. In the husks of both varieties small amounts of theobromine (less than 1 per cent.) were found, but no caffeine, which was present in small quantities in the kernels and cuticles of both varieties, was found in either. But little difference existed in the husks of both varieties in their contents of nitrogen and phosphoric anhydride, but those of Calabacillo contained the higher proportion of potash. When, however, the higher proportion of husk in the fruit of Forastero is taken it appears that this variety returns more nitrogen, more phosphoric anhydride and but little less potash to the soil in the waste husks than does an equal weight of the fruit of Calabacillo. But it requires double the weight of fruit of Forastero than of

Calabacillo to produce an equal weight of cured cacao, hence the return to the soil by the husks is more than twice as great in the case of the former as in that of the latter.

Assuming that the average yield here of the variety Calabacillo is 250 lb. and that of Forastero 150 lb. of cured cacao per acre respectively, we find that the amounts of the constituents of plant food removed from the land annually in the whole fruit, returned to the soil in the husks and either sold in the cured cacao or lost in the sweatings from the fermenting boxes are as follows:

POUNDS PER ACRE PER ANNUM

Variety of Cacao.	Calabacillo.			Forastero.		
Parts of fruit referred to.	Whole fruit.	Refuse husk.	Beans and pulp.	Whole fruit.	Refuse husk.	Beans and pulp.
Weight per acre.	6200	5000	1200	6900	6200	700
Nitrogen	20·15	8·85	11·30	19·04	11·78	7·26
Phosphoric anhydride .	9·42	4·10	5·32	10·14	5·95	4·19
Potash	29·01	22·70	6·31	25·39	22·19	3·20
Lime	2·60	1·95	·65	2·76	2·29	·47
Magnesia	7·44	4·75	2·69	8·21	2·66	1·95

Professor Harrison here makes a note of considerable importance to the grower, in the weights required of the two varieties to produce an equal weight of cured cacao. This arises from the very much larger weight of the shells of the pods in Forastero; a greater amount of waste material being produced.

The unavoidable loss per acre in British Guiana as compared with that in Venezuela given by Marcano, and with that in Guadeloupe reported by Boname is given on next page.

There is a general concordance in these results showing the low amounts of constituents necessarily removed from the soil in the production of a crop of cacao.

POUNDS PER ACRE PER ANNUM

	Demerara.		Venezuela.	Guadeloupe.*
	Calabacillo.	Forestero.	Varieties not stated.	
Nitrogen	11·30	7·26	7·8	7·3
Phosphoric anhydride	5·32	4·19	4·5	2·8
Potash	6·31	3·20	3·7	4·3
Lime	·65	·47	1·4	·4
Magnesia	2·62	1·95	1·	1·4

Manuring.—Where the Erythrina is used as a shade tree, manuring should be directed largely towards the upkeep of the potash and phosphates necessary to enable the shade trees to do their part as nitrogen collectors, and where no shade trees are used the mineral manuring ought to be more largely supplemented by nitrogen. Thus the following mixtures or mixtures of other materials yielding the same proportions of nitrogen, phosphates and potash per acre might be advisedly tried on cacao plantations :

	Erythrina used for shade.	Not shaded.
Nitrate of soda	1 cwt.	2 cwt.
Superphosphate of lime 36 per cent. soluble	¾ ,,	½ ,,
Potash sulphate	1 ,,	½ ,,

The materials should be well mixed and applied, in quantity according to the number of trees planted per acre, around each tree at a distance of about two to three feet from the stem.

An excellent way of applying phosphatic manures to the cacao-tree is by the use of slag phosphate. This has given highly satisfactory results, both in British Guiana and in Grenada. Where plantations are being newly started much advantage to the growth of the plants may be obtained by mixing the soil in the immediate vicinity of where the cacao is to be planted with from two to four pounds of slag phosphate meal.

Attention has also been directed to ascertaining the changes which the beans with the surrounding pulp

* Average return per acre assumed to be 450 lb.

undergo during the operations of fermenting and curing. For this purpose cured beans were analysed of the two varieties from the same plantation on which the samples of the fruits had been grown. The cuticles and the husks of the beans were separately examined, the composition of the whole bean being calculated from the figures thus obtained. The analyses were conducted on precisely the same lines and by the same methods as those of the various parts of the fresh fruit. Unfortunately, the two varieties are never, as far as our experience goes in the West Indian colonies, kept separate during fermentation, and we were forced to select our own samples from out of a very large sample of cured beans of the mixed kinds. Mr. J. H. Hart kindly examined the samples drawn, and considered them to consist of typical beans of the two varieties.

The following show the results of these analyses compared with those of the analyses of the similar parts of the fresh fruit dried as before described in the laboratory :

TABLE VII

COMPOSITION OF THE DRIED AND THE FERMENTED AND CURED BEANS, CUTICLES AND ADHERENT PULP OF "CALABACILLO"

	Dried.	Fermented and Cured.
Water	5·000	7·169
(1) Albuminoids	9·704	7·213
(2) Indeterminate nitrogenous matters	·681	3·509
(3) Theobromine	2·023	1·549
(4) Caffeine	·186	·103
Fat	38·181	40·744
Glucose	2·143	·909
Sucrose	·079	·024
Starch	5·980	5·249
Astringent matters	9·900	5·306
Pectin, &c.	1·822	2·671
Cacao-red	4·404	2·420
Digestible fibre, &c.	12·048	11·615
Woody fibre	5·515	5·503
Tartaric acid, free	·629	0·535
Acetic acid, free	nil.	·869
Tartaric acid, combined	·974	1·114
Iron peroxide	·044	·105
Magnesia	·559	·686
Lime	·134	·207
Potash	1·312	1·125
Soda	·355	·120

	Dried.	Fermented and Cured.
Silica	·022	·067
Sulphuric anhydride	·482	·055
Phosphoric anhydride	1·098	1·113
Chlorine	·044	·020
	100·319	100·000
(1) Containing nitrogen	·974	1·080
(2) " "	traces.	·640
(3) " "	·492	·315
(4) " "	·076	·099
Total nitrogen	1·542	2·134

TABLE VIII

CUTICLES OF CACAO BEANS, VARIETY "CALABACILLO"

	Dried.	Fermented and Cured.
Water	12·400	12·400
(1) Albuminoids	6·092	6·750
2) Indeterminate nitrogenous matters	traces.	4·006
(3) Theobromine	1·599	1·023
(4) Caffeine	·272	·355
Fat	2·946	4·000
Glucose	4·811	·476
Sucrose	·240	·143
Starch	6·271	4·865
Astringent matters	2·621	2·113
Pectin, &c.	5·408	6·140
Cacao-red	3·391	3·000
Digestible fibre, &c.	36·388	35·721
Woody fibre	8·932	9·840
Tartaric acid, free	2·913	·420
Acetic acid, free	nil.	·720
Tartaric acid, combined	2·010	3·450
Iron peroxide	·026	·057
Magnesia	·756	·999
Lime	·358	·266
Potash	1·260	1·821
Soda	·272	·219
Silica	·013	·200
Sulphuric anhydride	·139	·085
Phosphoric anhydride	·763	·912
Chlorine	·119	·019
	100·000	100·000
(1) Contains nitrogen	·974	1·080
(2) " "	traces.	·640
(3) " "	·492	·315
(4) " "	·076	·099
Total nitrogen	1·542	2·134

TABLE IX

KERNELS OF THE BEANS OF "CALABACILLO" DRIED AND FERMENTED AND CURED

	Dried.	Fermented and Cured.
Water	5·000	6·080
(1) Albuminoids	10·202	7·310
(2) Indeterminate nitrogenous matters	·809	3·406
(3) Theobromine	2·059	1·659
(4) Caffeine	·164	·058
Fat	44·574	48·400
Glucose	1·510	1·000
Sucrose	traces.	nil.
Starch	5·735	5·329
Astringent matters	7·624	5·972
Pectin, &c.	1·586	1·950
Cacao-red	4·497	2·300
Digestible fibre, &c.	7·287	6·182
Woody fibre	4·617	4·600
Tartaric acid, free	·120	·560
Acetic acid, free	nil.	·900
Tartaric acid, combined	·726	·624
Iron peroxide	·048	·115
Magnesia	·493	·621
Lime	·082	·196
Potash	1·283	·980
Soda	·364	·477
Silica	·024	·037
Sulphuric anhydride	·120	·051
Phosphoric anhydride	1·141	1·179
Chlorine	·028	·021
	100·000	10·0000
(1) Containing nitrogen	1·662	1·170
(2) ,, ,,	·129	·545
(3) ,, ,,	·634	·511
(4) ,, ,,	·047	·014
Total nitrogen	2·472	2·240

TABLE X

COMPOSITION OF THE DRIED, AND FERMENTED, AND CURED BEANS, CUTICLES AND PULP OF "FORASTERO"

	Dried.	Fermented and Cured.
Water	5·000	7·027
(1) Albuminoids	7·203	6·259
(2) Indeterminate nitrogenous matters	3·305	2·641
(3) Theobromine	1·461	1·402
(4) Caffeine	·331	·431
Fat	37·575	46·263
Glucose	1·263	·586

	Dried.	Fermented and Cured.
Sucrose	1·209	nil.
Starch	8·545	6·337
Astringent matters	6·053	3·588
Pectin, &c.	2·869	1·457
Cacao-red	2·620	2·883
Digestible fibre	10·420	9·070
Woody fibre	6·803	6·662
Tartaric acid, free	·687	·420
Acetic acid, free	trace.	·674
Tartaric acid, combined	·964	·981
Iron peroxide	·049	·078
Magnesia	·627	·676
Lime	·157	·163
Potash	1·033	·945
Soda	·096	·195
Silica	·022	·051
Sulphuric anhydride	·092	·016
Phosphoric anhydride	1·370	1·155
Chlorine	·089	·040
	99·843	100·000
(1) Containing nitrogen	1·152	1·001
(2) ,, ,,	·523	·423
(3) ,, ,,	·440	·422
(4) ,, ,,	·094	·122
Total nitrogen	2·209	1·968

TABLE XI

Cuticles of Cacao Beans, Variety "Forastero"

	Dried.	Fermented and Cured.
Water	11·840	11·840
(1) Albuminoids	6·603	6·130
(2) Indeterminate nitrogenous matters	traces.	3·394
(3) Theobromine	1·808	·909
(4) Caffeine	·306	·547
Fat	2·186	8·580
Glucose	5·200	·714
Sucrose	·473	nil.
Starch	6·779	3·682
Astringent matters	·561	4·350
Pectin, &c.	5·849	5·895
Cacao-red	3·662	3·100
Digestible fibre	34·100	31·292
Woody fibre	12·753	9·610
Tartaric acid, free	3·148	·420
Acetic acid, free	traces.	1·140
Tartaric acid, combined	1·823	3·456

	Dried.	Fermented and Cured.
Iron peroxide	·052	·248
Magnesia	·379	1·035
Lime	·156	·224
Potash	1·288	2·038
Soda	·078	·194
Silica	·015	·250
Sulphuric anhydride	·161	·122
Phosphoric anhydride	·509	·807
Chlorine	·265	·023
	99·994	100·020
(1) Containing nitrogen	1·056	·981
(2) " "	trace.	·543
(3) " "	·544	·274
(4) " "	·087	·155
Total nitrogen	1·687	1·953

TABLE XII

COMPOSITION OF THE KERNELS OF THE BEANS OF "FORASTERO," DRIED, AND FERMENTED AND CURED

	Dried.	Fermented and Cured.
Water	5·000	6·280
(1) Albuminoids	7·228	6·130
(2) Indeterminate nitrogenous matters	4·081	2·525
(3) Theobromine	1·321	1·480
(4) Caffeine	·332	·414
Fat	45·831	52·120
Glucose	·247	·566
Sucrose	1·373	nil.
Starch	9·043	6·750
Astringent matters	7·329	3·470
Pectin, &c.	2·068	·770
Cacao-red	2·311	2·850
Digestible fibre	3·969	5·762
Woody fibre	5·435	6·200
Tartaric acid, free	·057	0·420
Acetic acid, free	nil.	·600
Tartaric acid, combined	·729	·596
Iron peroxide	·048	·057
Magnesia	·680	·621
Lime	·153	·154
Potash	·951	·776
Soda	·101	·196
Silica	·024	·020
Sulphuric anhydride	·072	trace.
Phosphoric anhydride	1·565	1·210
Chlorine	·047	·043
	99·995	100·000

	Dried.	Fermented and Cured.
(1) Containing nitrogen	1·156	·980
(2) ,, ,,	·653	·404
(3) ,, ,,	·406	·457
(4) ,, ,,	·095	·119
Total nitrogen	2·310	1·960

When the compositions of these substances are given in percentages it is difficult to perceive the changes in composition which may have taken place during the fermentation and curing. The results obtained have therefore been recalculated on the assumption that the fat in the original beans as submitted to fermentation would undergo little or no change during the process; comparison of the compositions of the portions of the fresh fruit submitted to fermentation and of the corresponding amount of the product yielded is thus approximately obtained. In the germination of the seeds the fat is used up as food for the plantlet, but in the process of fermentation and sweating germination is so quickly checked that the more readily available sugars are not all absorbed or used up. Thence it is not likely that the fat will undergo appreciable change. These are given for both varieties in the following:

TABLE XIII

CHANGES TAKING PLACE IN THE KERNEL OF THE BEANS OF "CALABACILLO" DURING FERMENTATION AND CURING

	Fresh Beans.	Cured Beans.	Loss in Curing.
Water	37·637	3·675	33·962
Albuminoids	6·696	4·419	2·277
Indeterminate nitrogenous matters	·531	2·059	1·521
Theobromine	1·352	1·003	·349
Caffeine	·108	·032	·076
Fat	29·256	29·256	nil.
Glucose	·991	·604	·387
Sucrose	traces.	nil.	nil.
Starch	3·764	3·221	·543
Astringent matters	5·004	3·610	1·394
Pectin, &c.	·657	1·178	+ ·521
Cacao-red	2·952	1·390	1·562
Digestible fibre	5·112	3·737	1·375
Woody fibre	3·030	2·780	·250
Tartaric acid, free	·079	·328	+ ·259
Acetic acid, free	nil.	·544	+ ·544

	Fresh Beans.	Cured Beans.	Loss in Curing.
Tartaric acid, combined	·477	·377	·100
Iron peroxide	·032	·069	+ ·037
Magnesia	·324	·375	+ ·051
Lime	·054	·118	+ ·064
Potash	·842	·592	·250
Soda	·239	·288	+ ·049
Silica	·016	·022	+ ·006
Sulphuric anhydride	·079	·031	·048
Phosphoric anhydride	·749	·712	·037
Chlorine	·019	·012	·007
	100·000	60·442	

TABLE XIV

Results of Fermenting and Curing 100 Parts of the Beans with Cuticles and Pulp of "Calabacillo"

	Fresh.	Cured.	Loss in Curing.
Water	61·780	2·702	59·078
Albuminoids	3·904	2·719	1·185
Indeterminate nitrogenous matters	·274	1·168	+ ·894
Theobromine	·814	·584	·230
Caffeine	·075	·039	·036
Fat	15·361	15·361	nil.
Glucose	·862	·342	·520
Sucrose	·032	·009	·023
Starch	2·406	1·979	·427
Astringent matters	2·776	2·000	·776
Pectin, &c.	·733	1·007	+ ·374
Cacao-red	1·772	·912	·860
Digestible fibre	4·847	4·379	·468
Woody fibre	2·219	2·074	·145
Tartaric acid, free	·253	·201	·042
Acetic acid, free	nil.	·327	+ ·327
Tartaric acid, combined	·392	·420	+ ·028
Iron peroxide	·018	·039	+ ·021
Magnesia	·225	·258	+ ·033
Lime	·054	·078	+ ·024
Potash	·528	·424	·104
Soda	·143	·045	·098
Silica	·009	·024	+ ·015
Sulphuric anhydride	·194	·021	·173
Phosphoric anhydride	·442	·419	·023
Chlorine	·012	·007	·011
	100·132	37·538	

TABLE XV

RESULTS OF THE FERMENTATION AND CURING OF 100 PARTS OF THE BEANS, CUTICLES AND PULP OF "FORASTERO"

	Fresh.	Cured.	Loss in Curing.
Water	58·261	2·570	55·754
Albuminoids	3·165	3·233	·932
Indeterminate nitrogenous matters	1·452	·940	·510
Theobromine	·641	·500	·141
Caffeine	·145	·154	+ ·009
Fat	16·509	16·509	nil.
Glucose	·555	·209	·246
Sucrose	·531	nil.	·531
Starch	3·754	2·261	1·493
Astringent matters	2·659	1·280	1·379
Pectin, &c.	1·261	·520	·741
Cacao-red	1·151	1·028	·123
Digestible fibre, &c.	4·578	3·236	1·342
Woody fibre	2·989	2·377	·612
Tartaric acid, free	·302	·150	·152
Acetic acid, free	trace.	·240	·240
Tartaric acid, combined	·423	·350	·073
Iron peroxide	·021	·028	+ ·007
Magnesia	·275	·241	·034
Lime	·069	·058	·011
Potash	·454	·337	·117
Soda	·042	·069	+ ·027
Silica	·009	·018	+ ·009
Sulphuric anhydride	·040	·006	·034
Phosphoric anhydride	·602	·412	·190
Chlorine	·039	·014	·025
	99·927	35·679	

TABLE XVI

CHANGES TAKING PLACE IN THE KERNELS OF THE BEANS OF "FORASTERO," DURING FERMENTATION AND CURING

	Fresh Beans.	Cured Beans.	Loss in Curing.
Water	36·567	3·687	32·880
Albuminoids	4·829	3·599	1·227
Indeterminate nitrogenous matters	2·725	1·482	1·243
Theobromine	·882	·869	·013
Caffeine	·222	·243	+ ·021
Fat	30·602	30·602	
Glucose	·165	·332	+ ·167
Sucrose	·917	nil.	·917
Starch	6·038	3·963	2·075
Astringent matters	4·894	2·037	2·857
Pectin, &c.	1·380	·452	·928
Cacao-red	1·543	1·673	+ ·140
Digestible fibre	2·821	3·377	+ ·556
Woody fibre	3·458	3·640	+ ·192

	Fresh Beans.	Cured Beans.	Loss in Curing.
Tartaric acid, free	·038	·246	+ ·218
Acetic acid, free	nil.	·352	+ ·352
Tartaric acid, combined	·487	·350	·137
Iron peroxide	·032	·033	+ ·001
Magnesia	·454	·364	·090
Lime	·105	·090	·015
Potash	·635	·455	·080
Soda	·068	·115	·057
Silica	·016	·012	·004
Sulphuric anhydride	·048	trace.	·048
Phosphoric anhydride	1·045	·710	·335
Chlorine	·032	·025	·007
	100·000	58·708	

In the case of the variety Calabacillo we find that 100 parts of the fresh material submitted to fermentation and curing lose 6·25 per cent. of their weight, of which 59 is water and 3·5 is organic and mineral matters. In the kernels of the beans the loss on 100 parts amounts to 39·4, of which 6·5 parts consist of solid constituents.

In the variety Forastero 100 parts of the material submitted to fermentation and curing yield 35·6 parts of cured cacao, a loss of 64·4 per cent. ensuing, of which 55·7 is water and 8·7 solid constituents. The kernels of the beans lose 41·3 per cent. during fermentation and curing, of which 8·4 parts consist of solid constituents.

It is evident that when submitted to a similar fermentation and curing, beans of the variety Forastero lose a higher proportion of their weight than do the small flat beans of Calabacillo.

In both cases a considerable loss of the albuminoid constituents ensued, with, in the case of Calabacillo, an increase in the indeterminate nitrogenous matters. In Forastero, a loss of the latter also appeared to have taken place. In both cases we find a loss of the alkaloidal constituents has taken place, this being greater in Calabacillo than in Forastero. A marked loss of the sugars has occurred, and also of the starch, pectin, gums, and digestible fibre, this being much greater in the case of Forastero than in that of Calabacillo. The astringent matters and cacao-red have also decreased in about equal

proportions on the two varieties. Little change has taken place in the total quantities of tartaric acid present, but the fermented and cured beans contain a small proportion of acetic acid not present in the original material. Both varieties have lost some of the more soluble constituents of their mineral ingredients.

Comparison of the losses apparently undergone by the whole material submitted to fermentation, and by the kernels of the beans, leads to the conclusion that, as might be expected, a certain amount of change in place has occurred in the constituents of the kernels of the beans and the cuticles and pulp. The kernels show a much more marked loss of astringent matters than do the whole beans, and to this loss much of the improvement in flavour must probably be due.

It is also seen by examination of these results that it is probable that during the sweating process slight changes in the position of the constituents of the beans of the two varieties have taken place, leading in some cases to apparent gains of constituents in one or other of the kinds. It was found that the original sample consisted approximately of one-fifth beans of Calabacillo and four-fifth beans of Forastero.

The following shows the losses resulting from the fermentation of the mixture, and, we think, may be considered as a fairly reliable indication of the changes which ordinarily take place during the fermentation and curing of cacao:

TABLE XVII

LOSSES RESULTING FROM THE FERMENTATION AND CURING OF A MIXTURE OF BEANS OF "CALABACILLO" AND "FORASTERO"

Water	56·419
Albuminoids	·982
Indeterminate nitrogenous matters	·229
Theobromine	·159
Caffeine	nil.
Fat	nil.
Glucose	·301
Sucrose	·429
Starch	1·280
Astringent matters	1·258

Pectin		·518
Cacao-red		·270
Digestible fibre		1·167
Woody fibre		·518
Tartaric acid, free		·130
Acetic acid, free	+	·257
Tartaric acid, combined		·053
Iron peroxide	+	·010
Magnesia		·021
Lime		·004
Potash		·114
Soda		·002
Silica	+	·010
Sulphuric anhydride		·030
Phosphoric anhydride		·156
Chlorine		·022

There has occurred a loss in almost all constituents of the cacao, the only gains being in acetic acid, a product of the fermentation, and in iron peroxide and silica due to dirt and dust picked up during the final drying. As a check on the accuracy of these results, a sample of the liquid running from the sweating-boxes was obtained, the constituents of which consist of matters removed from the fermenting material, and was found to contain, with the exception of theobromine, either the missing soluble constituents or the soluble products of their alteration and of that of the less soluble carbohydrates.*

TABLE XVIII

COMPOSITION OF THE SWEATINGS FROM A MIXTURE OF CALABACILLO AND FORASTERO

Water	84·817
(1) Albuminoids	·062
(2) Indeterminate nitrogenous matters	·250
Glucose	11·604
Sucrose	·638
Astringent matter, &c.	·354
Alcohol	·180
Tartaric acid, free	·340
Acetic acid, free	·892
Acetic acid, combined	·290
Iron peroxide	·038
Magnesia	·074
Lime	·029
Potash	·054
Soda	·004
Sulphuric anhydride	·021
Phosphoric anhydride	·038
Chlorine	·007
	100·000
(1) Containing nitrogen	·010
(2) „ „	·040

* Showing where the loss went.—J. H. H.

Examinations made by us of the process of sweating showed clearly that at first an alcoholic fermentation takes place, accompanied by a rise in temperature of the material; later, a little acetic ether is produced either as a direct product of fermentation or by the interaction of the alcohol and the acetic acid produced, and, finally, the fermentation becomes an acetic one, the temperature in the fermenting boxes gradually rising so high as practically to stop the alcoholic fermentation.

The results of the examinations and analyses show that the process of fermentation or sweating in cacao consists in an alcoholic fermentation of the sugars in the pulp of the fruit accompanied by a loss of some of the albuminoid and indeterminate nitrogenous constituents of the beans. Probably the albuminoid constituents are first changed into amides and other simpler combinations, which may be further broken up during the process of fermentation. Some parts of the carbohydrates other than sugars undergo hydrolysis, and either escape in the runnings from the boxes in the form of glucose or undergo in turn the alcoholic and acetic fermentations.

During this change some of the astringent matters to which the somewhat acrid taste of the raw beans is due are also hydrolysed, and thus a marked improvement in flavour is gained. Small quantities of the mineral constituents, principally of potash and phosphoric acid, are removed from the beans in the liquid escaping from the fermenting material. A slight loss in woody fibre is shown, which may be due to loss of portions of the cuticle during the operation of drying, or to changes in it by hydrolysis during fermentation.

This work has necessarily only resulted in a partial and incomplete study of the results of fermentation. The study of the changes which take place in various kinds of beans and during variously modified conditions of fermentation must be left to botanists and chemists in colonies and countries where cacao is an important product. Work already done in this line is fully compensated if it leads

ANALYSIS OF CACAO SOILS. (ONE VENEZUELAN AND TEN TRINIDAD)

	Venezuela (Good soil.)	Pluck.		Ortinola.		La Compensacion.		San José.		Monserrat.		Sangre Grande.			
		I. Blk.	II. Red.	I. Red	II. Blk.	I.	II.	I.	II.	I.	II.	I.	II.	III.	IV.
COMPOSITION OF AIR-DRIED SAMPLES															
Water	10·74	9·47	9·20	1·60	1·04	5·82	4·32	4·70	4·98	4·23	2·58	6·04	3·56	9·48	3·66
Dry Soil	89·26	90·53	90·80	98·40	98·96	94·18	95·68	95·30	95·02	95·77	97·42	93·96	96·44	90·52	96·34
	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000
COMPOSITION OF THE DRY SOIL															
Loss on Ignition	7·610	7·700	8·200	3·850	2·870	9·890	6·700	3·820	9·000	5·340	3·660	6·641	6·097	7·004	8·948
Iron Oxide	6·200	14·920	14·210	5·000	4·410	12·500	13·330	7·880	9·690	3·860	3·370	2·327	2·343	2·143	2·440
Alumina	—	—	—	—	—	—	—	—	—	4·410	2·450	3·798	5·171	5·652	5·313
Lime	·594	·540	·517	·700	·513	·403	·231	·284	·305	·218	·133	·128	·084	·124	·148
Magnesia	·782	·291	·376	·101	·076	·246	·212	·205	·208	·104	·246	·445	·498	·405	·284
Potash	·392	·264	·233	·212	·218	·250	·239	·237	·247	·126	·114	·183	·223	·267	·217
Soda	·177	Not determined			—	Not determined			—	·286	·267	·173	·021	·081	·142
Phosphoric Acid	·147	·231	·237	·142	·155	·149	·120	·208	·222	·139	·118	·133	·096	·117	·116
Sulphuric Acid	·036	·056	·077	·029	·025	·043	·048	·027	·039	traces.	traces.	·111	·053	·102	·025
Chlorine	·016	·004	·044	·104	·006	·019	·008	·005	·007	·005	·006	·005	·006	·008	·093
Insol. Silicates	84·046	75·994	76·146	89·962	91·727	76·510	79·142	87·334	80·282	85·512	89·636	86·056	85·408	84·097	82·364
	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000
Containing Nitrogen	·071%	·143%	·127%	128%	·110%	·067%	·073%	·067%	·110%	·087%	·093%	·131%	·107%	·140%	·165%
" Carbon	—	—	—	—	—	—	—	—	—	—	—	·234	·454	·139	·224
Equal to humus	·225	·346	·292	·251	·298	·290	·346	·375	·351	·249	—	·403	·784	·242	·386
Nitrogen as Nitrates	·00636	·0012	·0915	·00323	·00157	·00119	·30097	·00072	·00094	·0010	·0009	·00253	·00298	·00235	·00335
READILY AVAILABLE POTASH AND PHOSPHATES															
Potash	·1707%	·138%	·1341%	·1225%	·1466%	·1052%	·1071%	·1698%	·1177%	·086%	·059%	·0914%	·1290%	·1162%	·0881%
Phosphoric Acid	·082	·077	·091	·071	·078	·102	·101	·101	·087	·062	·104	·0510	·0564	·0159	·0465

others more favourably situated to take up the study of this interesting and intricate subject, and, at any rate, the record of the investigation may be of some service and guidance to the owners and managers of plantations, and to those contemplating purchasing suitable land for establishing plantations.

In the remarks which precede Professor Harrison's paper, quoted here, it was shown that chemical work on produce, which it is difficult to identify on account of the presence of innumerable seedling varieties, cannot be expected to afford wholly satisfactory results; but it is confidently hoped that the introduction of standard varieties which has been suggested will enable chemists to give improved effect to the various points in connection with the chemistry of this valuable product.

The preceding table of analyses made in the Government Laboratory of Trinidad upon samples of Trinidad and one Venezuelan sample of soils, on which cacao is grown, is given for comparison with those made by Professor Harrison:

Professor Harrison supplies tables showing results of the examination of eighteen samples of soil, ten of them showing the constituents of a good soil, and eight showing contents of a poor soil, the latter samples being taken from lands known to be poor, and the former from lands known to be rich, taking the average of crops for several previous years.

The Trinidad table contains figures which appear to be directly comparable with those in Harrison's tables. Both tables show a wide range of variation, and show fairly well the value of the different soils. A comparison of figures —in so far as they are stated in identical terms—appears to show that Trinidad and Venezuelan soils contain a larger percentage of insoluble silica and silicates and less amounts of organic matter than the greater number of those analysed by Professor Harrison, with the exception of the Trinidad and St. Vincent samples. Some of the Trinidad soils are shown to contain over 14·9 per cent. of iron oxide and alumina taken together, while in one case

35·7 per cent. of iron and alumina are shown by Harrison as occurring in a Grenada soil, the proportions being 18·6 per cent. iron and 17·1 per cent. alumina. In one of Harrison's "poor soils" as much as 49·2 per cent. of iron and alumina was found, the same sample containing 12·8 per cent. of organic matter, which is a higher percentage than any in the Trinidad soil. In all his "good soils" the percentage of organic matter and combined water is high, with the exception of the two samples from St. Vincent and Trinidad, while the analyses made in the Trinidad Laboratory show a much lower percentage of organic matter, given in the table as "loss by ignition."

Professor Harrison concisely states that

Chester J. Hunn

> A good cacao soil should be one capable of yielding to the tree in the course of years a somewhat high proportion of the important constituents of plant-food without exhaustion, and also capable of rendering again available the large quantities of manurial matter which return to it. . . . And it must be one in which nitrification readily takes place.

In discussing questions of the exhaustion of soils, &c., it should not remain unnoticed that in tropical countries a factor is present which the writer has termed "the incidental increment of plant food." This factor is, however, in general disregarded.

Soils are found, for instance, to contain a certain constituent in definite quantity. The trees are said to require a certain quantity of such constituent year by year, and the popular argument follows that when the total is used up the land becomes "exhausted." Well, it has been found, say, that they require a certain amount of phosphoric acid; the land when examined is proved to contain an amount that would last for ten years. The ten years pass, and according to analysis the land should be exhausted, but good crops continue from year to year, and have continued for half a century to do so, on land supposed to contain only a ten years' supply. It is one of the strong arguments of the manure merchants that "what is annually taken away exhausts, and must be artificially supplied." In our case it is not supplied artificially, but apparently naturally, and by methods which are not yet fully understood, and

therefore the presence of such food has been termed the "incidental increment." Such incidental supplies do not appear to be taken into account by the chemist. That they exist has been proved by several examples under our notice.

It is well known that a large amount of epiphytic growth occurs in tropical areas, especially among plants belonging to the order *Bromeliacea*. These plants cover the branches and stems of trees, and are especially plentiful in cacao estates, both on the shade trees and on the cacao-tree itself.

A large shade tree having to be cleaned of one of these plants, a sample was taken and sent for analysis, when the following was given as the result: Water, 78·13 per cent.; ash, 0·89 per cent.; organic matter, 20·98 per cent. Now, these plants are so constructed as to maintain water in the axils of their leaves, some holding as much as a quart at a time. In this water insects of numerous kinds drown, and vegetable matter is deposited, and an examination of a sample of it showed that it contained total solids 0·184 per cent., organic matter 0·160 per cent., ash 0·024 per cent. This result may appear small, but when it is considered that the water contained in the plant overflows with every shower it is seen what a large quantity of manurial matter may be thrown upon the land during the course of a year.

The plants themselves also are constantly upsetting and freeing themselves from the branch, and falling to the ground, adding, as will be seen, some 21 per cent. of their weight of organic matter to the soil on which they fall. Phosphoric acid is also required, say 0·5 drachms per tree. The bones of a snake, bird, or small rodent would furnish the required amount. That it must get there we know, as the produce contains it; but there is at present no way of estimating or measuring the quantity, although the planter can fairly calculate upon a constant supply. When the want of "incidental increment" makes itself apparent by exhaustion, the planter must then adopt artificial supply, but not until the want of it is plainly proved.

In Trinidad, estates are known which have been producing cacao with undiminished average yield for nearly a century, without anything more than "incidental increment," which clearly shows that it amounts to a quantity which is far from inconsiderable. The inference clearly is, that supplies are afforded by Nature in a way not yet sufficiently understood or taken into account.

Trees require supplies, and trees obtain supplies, as evidenced by their yield of fruit containing the same materials. How they obtain them and whence they come are questions deserving the serious attention of tropical planters.

It must not be understood from the foregoing that the writer deprecates manuring; for it is certain that given the want of it, better crops are obtained with than without it, and the want of it may be easily found by the simple experiment of applying it, watching the result, and acting accordingly.

The factor of soil content, though of high importance, is considered to have less influence on the quality of the produce grown than the possession by the tree of certain inherent and special qualities which enable it to perfect its produce in definite form, colour, flavour, and aroma, and no other. We cannot make a Jersey cow out of a Hereford by feeding it with certain food, neither can we reap a fine quality of cacao from a low cross-bred strain by supplying it with manures or fertilisers of any special kind, or by certain treatment during fermentation, a fact which can be readily proved. We can increase the quantity of produce by extra manuring or extra food, in the same way as we can increase the yield of grain or the yield of an apple-tree, but the *quality* depends on the class of tree planted, and not (except in a minor degree) upon the quantity or quality of manure applied. A tree turns its food-supply into material in the way described of old: "Every tree shall produce fruit after its kind." I have written on this point strongly because there exist in the West Indies and also in other countries ideas that the

agriculturist can alter the quality of fruit by manuring, that certain fruit will grow on certain soils and not on others, and that soil affects flavour, &c. These I consider are largely fallacies which have hindered progress in cacao planting, as although praiseworthy efforts have been made they have not been carried out on the right lines, which, I suggest, are the selection, development, and cultivation of standard named varieties of cacao of different standards of quality propagated solely by budding or grafting. If it be Calabacillo, let it be a good Calabacillo ; if Forastero, let it be the finest possible ; if Criollo, Nicaraguan, or Venezuelan, let it be the best, and the best to suit the market, or in short, follow with cacao the methods of fruit-growing as now understood and practised by leading orchardists all over the world.

CHAPTER XVII

TEMPERATURE AND CLIMATE

THAT Trinidad possesses a climate suitable for the growth of cacao is indisputable, and it may be assumed that all countries having similar meteorological conditions will also be suitable for the cultivation of cacao, provided the soil conditions are favourable, and the lands are well protected from wind storms.

The mean annual meteorological records for twenty years, from 1888 to 1907, are as follows, no later being obtainable:

TRINIDAD BOTANICAL DEPARTMENT RECORDS, 1888 TO 1907 = 20 YEARS

Barometer mean of morn and even records.	Thermometer.		Mean annual temp.	Mean annual relative humidity.	Rainfall mean Total' 20 years.	Station 66·60 feet above mean sea level.
	Mean max.	Mean min.				
Inches.	Degrees Fahr.	Degrees Fahr.	Degrees Fahr.	Saturation = 100.		
29·964	87°·5	69°·9	78°·5	79·0	66·60	

The above rainfall may be taken as a fair average for the whole island of Trinidad, as records for many years, taken from upwards of a hundred stations, show that the mean average for the whole island per annum falls within a point or two of the annual fall at the Meteorological Station of the Botanical Department.

It will be seen from the table given that the average humidity is 79·0, taking Saturation at 100. In some districts of the island the amount of humidity or moisture

suspended in the atmosphere is probably much greater than at the Botanic Gardens. It may therefore be held that what is indicated for this district is the lowest permissible amount for a district suitable for cacao cultivation, and that such crops would be benefited by a greater amount of humidity.

The annual rainfall at the Botanic Gardens for the past twenty years shows an average of 66·60 in., and in the longer period of forty-six years this average shows as 66·09 in.

In my experience, humidity is a much more important feature in plant growth than temperature alone, and few plants suffer more than cacao when the year is deficient in moisture. Even in the driest weather in Trinidad the hygrometer shows that during the later portion of the night and early morning, the moisture in the air closely approaches to saturation, and it is only the readings of the period between 10 A.M. and 4 P.M. which reduce the record to the average of 79.

Cacao can stand a certain amount of severe drought for short intervals, but districts which are subject to continued drought are certainly not suitable for the cultivation of the cacao-tree, as under such conditions the tree will certainly perish.

Cacao cannot stand a persistent breeze of wind of even medium strength, as its young leaves are extremely tender; they suffer badly where cut by wind, and their functions are seriously affected. Many estates, otherwise perfectly suitable, are rendered useless for cacao cultivation, if situated in a position which is reached by trade winds, such as occur on the north-east of many West Indian islands. This point should be well noted by the intending purchaser of land, and guarded against. If land is purchased in such a situation, the slopes facing the wind should never be planted with cacao, while the opposite or reverse slopes, which are protected, may be valuable lands for the purpose.

Countries in which the mean annual rainfall is greater

than in Trinidad may not possess the same humidity, and therefore are not as suitable for the cultivation of our plant, and countries on the other hand which exhibit a smaller annual rainfall may be suitable for cacao cultivation owing to the presence of the requisite amount of humidity; for in no country is the humidity fully determined by, or coincident with the rainfall, as it is often influenced by other outside conditions. On the south side of the island of Jamaica, for instance, although a similar temperature prevails as in Trinidad, the humidity shows a remarkable divergence from our record, and in that fact shows plainly that the district is unsuited for the growth of cacao. There are other situations, however, in that island where the requisite humidity can be obtained, and where the tree thrives exceedingly well and produces large crops of fruit.

The planter must not take it for granted, therefore, that because he is in the West Indies, Central or South America, &c., in a climate exhibiting a temperature similar to Trinidad, that he can rely upon such a situation or climate as being suitable for cacao, for he cannot do so, as he may find to his cost, if he attempts the venture. Having learnt what the cacao-tree requires in the matter of moisture or humidity, the planter must examine for himself and depend on his own judgment in selecting a spot for a cacao plantation, especially if it happens to be in a country where the cultivation of that product has not preceded him.

In the West Indies, as in other countries, the higher the elevation the cooler the temperature, and the greater the moisture during the hours of darkness, and in hilly situations in well-sheltered positions cacao has been found to thrive, owing to the presence of sufficient humidity, in places where the temperature is much below the mean annual of the finest cacao districts.

Persons who have to send home returns are often asked, Why are you complaining of drought when I see your rainfall for the season has been normal? This may happen owing to the different time of day at which the precipitation

of vapour takes place. This was especially noticeable in Trinidad a few years since, when, although the rainfall was above the average, the river supply was scanty. This was apparently owing to the fact that the greater part of the falls took place in early daylight hours, succeeded by full power sun for several hours later. When the precipitation takes place in night hours and falls steadily, very little or no evaporation takes place, and the water finds its way into the ground, to be retained some way below the surface, and in the end finds its way underground to the rivers. Hence it is seen that at times when heavy showers fall with an intermission of bright sunny hours, they cannot be counted upon by the cultivator to supply the full complement of moisture required, although the actual amount, had it fallen in suitable time of the day, would have been ample. Planters can, therefore, suffer from drought even when a normal rainfall is registered. Rainfall during the crop seasons is at times a terror to the planter, especially when he has a large amount of cacao upon his floors, dependent upon the sun for drying. Happily, long-continued rain-storms are more the exception than the rule ; and intermittent showers with sun between allow of curing work being carried on, although not so successfully as in continuously dry weather. Continuously dry and wet weather are both bad for the field, as hindering work, and also for their effect upon the trees. Cacao-trees may flower and their fruit will "set" in either dry or wet weather, and a large number of fruit will blacken and drop. What is exactly the cause of their dropping has not yet been fully determined, and it has been suggested that microscopic fungi play no small part in the matter, but the evidence at present in favour of this view is by no means conclusive, although there remains no doubt that parasitic fungi are dangerous enemies. Meanwhile the fact remains that loss of crop occurs in both wet and dry weather, and this would point to different classes of parasitic fungi existing, the one killing in the wet, and the other in the dry. The solution will possibly be found "some day," a day not yet

in sight, although it must be confessed that progress is being made along some of the lines of observation, and planters are beginning thankfully to take advantage of such scientific knowledge as has been placed within their reach, but at present with only lilliputian effect, for it appears to require a "Gulliver" to put out the fire of disease which is believed by some to have started during recent years, although there is strong evidence that most of the diseases are endemic, and have existed in the forest from past generations. Some young planters are commencing study with good effect, and it is upon the united effort of men of the younger generation that the continued success of the cacao interest will depend; for it is certain that no single specialist or worker can solve the problem of the control of disease on cacao estates, though he may do much useful work. At present the tendency is to centralise work in this direction, and to carry on investigations based upon imperfect data, and why?—for fear of another stepping in, getting an organism determined or a disease diagnosed before A, B, or C has worked it out. It is thought, however, that if the line of work were publicly laid down, many a volunteer would be very glad to assist; but we fear official prejudice is somewhat against this perhaps too radical a view of the matter in question. While working on parasitic fungi the meteorological problem has to be considered, and the questions arise: Are parasitic fungi solely responsible for the falling of young pods? Are the meteorological conditions of the moment responsible? Or is the bearing power of the tree determined by its strength, and are the pods shed naturally, in order that it should not reduce its vitality by excessive production? In a proper examination of these questions it is probable the solution will be found.

CHAPTER XVIII

YIELD, VALUE AND PRICES OF CACAO

The yield per tree depends, first, upon the character of the tree, and, secondly, upon the quality of the land in which it is planted. Some trees naturally yield more than others, as may be seen in fruit orchards in any part of the world, the aim of the cultivator being to secure types which yield well. How to secure such trees has already been discussed. That yield can be increased by manuring is certain, where the condition of the soil is such as to allow it; but to force trees with too much manuring tends to shorten their period of existence. Sufficient manure is good practice, over-abundance is bad. The yield per 1000 trees is probably the best test of the value of estates, especially if the records have been reliably kept and the seller is able to give authentic reference to crops harvested during a period of years.

Trees of the same size, planted side by side, will largely differ in yield when only seedlings are used. The maximum yield of some seedlings will not be more than 1 lb. of dry cacao annually, while others have been known by the writer to yield as much as 15 lb. 3 oz. annually of dry cacao, and others have recorded as much as 30 lb. per tree. From this it has been deduced that, given trees of special character, the annual crop might be easily increased.

In the Bulletin of the Botanical Department of Trinidad, April 1907, I asked the question, "What is the possible crop of a tree in full bearing?" and suggested that careful observations should be made by planters, under which the number of pods picked from selected trees should be recorded. This was taken up by a leading Trinidad

planter, and the following table gives the results obtained:

BROWN'S TABLE *

Date harvested.	Number of Trees observed. 1	2	3	4	5	6	7	8	9	10	11	12	Total number of Pods harvested.
1907.													
Jan. 3 .	9	12	15	18	5	13	17	15	29	24	13	6	176
April 2 .	10	12	5	13	29	8	18	14	7	13	31	42	202
,, 24 .	11	1	4	1	15	6	4	0	1	6	8	7	64
May 23 .	22	2	8	6	36	1	6	14	4	4	15	16	134
June 24 .	46	4	16	16	83	5	30	34	10	11	24	42	321
July 22 .	56	7	8	30	27	5	8	55	13	1	5	34	249
Aug. 27 .	3	2	1	1	1	0	1	6	3	0	2	6	26
Sept. 24 .	0	1	0	2	4	6	0	9	2	4	1	8	37
Oct. 22 .	6	0	6	0	4	7	5	4	1	12	6	12	63
Nov. 12 .	6	0	11	1	12	6	16	5	9	8	6	19	99
Dec. 3 .	14	6	23	4	4	3	15	11	13	38	5	3	139
,, 17 .	32	14	42	3	12	12	56	11	50	41	23	11	307
Year's totals	215	61	139	95	232	72	176	178	142	162	139	206	1817
1908.													
Jan. 3 .	57	40	113	11	22	21	85	29	38	84	22	11	
,, 9 .	25	31	68	17	6	19	47	17	14	75	36	6	
Feb. 20 .	38	10	31	16	18	19	59	28	24	34	30	37	
	120	81	212	44	46	59	191	74	76	193	88	54	1238

The six best trees in the table for the year 1907 are Nos. 5, 1, 12, 8, 7, and 10, which show an average yield of 194·8 pods each. Adding the first two months of the following year, the trees showing the heaviest yield for the fourteen months are Nos. 7, 10, 3, 1, 5, and 12, with an average yield of 324·3 pods each. The average during the year 1907, for twelve trees, was 157·4 pods, and for the fourteen months 254·5 pods.

The table showing a year's produce from selected trees, being an actual yield, is strong evidence that progress on the lines of selection of prolific and disease-resisting kinds will be the best means of increasing the annual yield, and that there is a very large margin between the yield per tree here found and the yield per tree with which estates are at present credited. If trees under ordinary culture can produce the yield of our table, it is surely possible, given well-planted trees of the same character (produced by

* Information supplied by J. Brown, Esq., San Diego Estate, Trinidad.

budding grafting), materially to increase the annual yield, leaving out all reference to increase by manuring.

The question which originated the table was also noted by the *Tropical Agriculturist* of Ceylon, a valuable paper always on the *qui vive* for information on cacao matters, and reference was made by the editor to Wright's work, in which various interesting estimates and returns of yield are to be found, which the author modestly terms a "synoptical account of the results which have been published." He says:

> The average cacao estate possesses from 200 to 300 trees per acre, and an annual yield of from less than one to over five pounds of dry cacao per acre has been recorded. The cacao-trees may begin to bear flowers and fruits in their third and fourth years, but it is usually considered advisable to prune all the flowers which occur in the first blossom; this prevents the concentration of valuable mineral and proteid constituents in the seeds and allows these materials to be used in the development of a better vegetative system, from which heavier crops may be subsequently expected. Many planters consider that the fruits borne on the main trunk are better in quality and weight than those on branches, and on estates where the development of a single or main stem with the minimum number of branches and suckers is aimed at, these differences appear to require consideration.

Personally, the writer is of opinion that the pods which are nearest to that section of the tree which has the best circulation of sap will have the advantage over those where the wood is old and hard and the growth stunted; but when the whole plant is healthy and vigorous, little, if any, difference in rate of growth will be observable, or in weight and quality.

Mr. Wright's returns of yield are very interesting, but it would not be just to quote them in detached portions, as their value can only be estimated by consulting the pages of his book, where they are arranged in due order for comparison. At page 194, however, he gives a table of yield per tree, taken from various sources as follows, which I may quote, as it gives returns comparative with Trinidad yields:

Nicaragua	1 lb. per tree	per annum.
Ecuador	1 lb. ,,	,,
,,	1½ to 2 lb. special trees	,,
Surinam	1·5 Kg. to 3 and 4 Kg.	,,
Mexico	5 to 8 lb. ,,	,,
,,	1½ lb. (Christmas yield).	

For the West Indies

Trinidad	$1\frac{1}{2}$ to $1\frac{3}{8}$ lb. per tree (Preuss).
"	2 to 3 lb. per tree (Oliver).
"	464 grammes per tree or 1·02 lb. (Royal Commission).
"	1·5 to 1·6 lb. per tree (Hart).
"	1·4 lb. per tree (De Gannes).

In January, 1908, I published an account of the yield of a single tree in the Botanical Gardens, Trinidad, the crop of which was harvested under the author's personal supervision, as follows:

Yield of a single tree, Theobroma cacao var. *Forastero amelonado :*

Year.		lb.	oz.	
1907	February	7	8	dry cacao.
"	May	3	14	"
"	August	2	15	"
"	December	0	14	"
		15	3	"

This is the yield of a tree which received nothing but ordinary cultivation, was not planted in any specially prepared land, and, in fact, received little attention. Brown's table does not show the return in dry cacao, but calculating that ten to twelve pods make a pound of dry cacao, the value of the number of pods can readily be ascertained.* It also shows not only the yield of the best trees, but the fluctuations of the yield during the year; also the fact that a cacao-tree is seldom out of bearing; and it explains as much as a single year can, the course of the crop seasons and the variations of the yield during the different months. What is called the "June crop" appears in this table—in May, June, and July. What is called the "November crop" began to appear only in December, and lasted, as will be seen, into the following year.

The crop periods in any one year may be as much as six or more weeks earlier or later, and may extend continuously through several months, a result entirely dependent upon the seasons or meteorological conditions.

* The weight of dry cacao obtainable is, of course, dependent upon the variety under cultivation, some of which would give 1 lb. from seven pods and others 1 lb. from fifteen or more pods.

As will be seen from the Trinidad returns the harvests are uneven, and the crop often runs over the statistical year into the following one, so that a certain moiety falls into the preceding and following years.

Wright's tables on the periodicity of cacao crops are also interesting, and are in accord with Trinidad observations, and should be consulted by all cacao planters.

The period of growth of a cacao pod from flower to maturity extends from four and a half to five months, *i.e.*

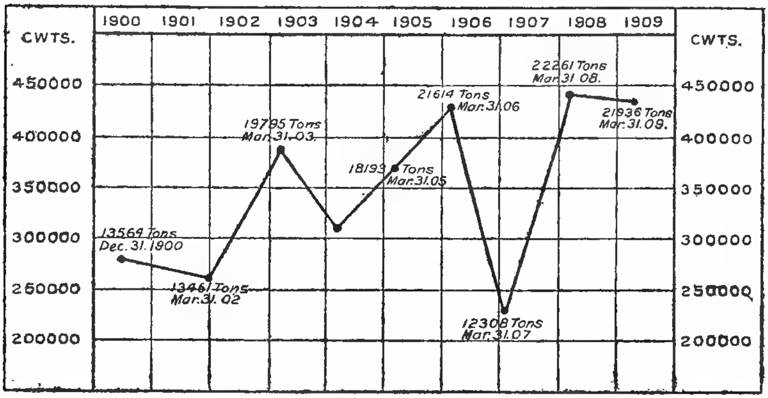

FIG. 57.—Exports of Trinidad Cacao, 1900–1909

from the opening of the flower to the ripening of the pod, but this period may be extended, owing to the facility with which the mature pods remain in the ripened state upon the trees for some days or even weeks after they have reached full maturity It is *not* good practice, however, to allow them to remain too long upon the tree or the quality of the produce will suffer considerable deterioration. If they remain much too long, it will be found that the seeds have begun growth in the pods, and instead of marketable material there will be nothing but a mass of matted roots. If they commence to grow and the radicle or first root pierces the "shell" of the seed, it leaves an aperture which allows of the entrance of mould fungi while drying, and thus lowers the value of the sample,

The facility with which pods hang for a time upon the trees without hazarding quality assists generally the economy of the harvest work.

To return to Brown's table of yield, we find the average for the year was 151·4 pods, and taking ten pods as equal to 1 lb. of dry cacao we have an average yield per tree of over 15 lb. By extending these proportions we calculate bags per 1000 trees, and find that it amounts to 15,000 lb. or 90·9 bags of 165 lb. per 1000 trees. An ordinary yield is calculated from 10 to 15, but some report crops of from 20 to 25 bags per 1000. It has been recently reported in Trinidad that yields of 25 to 30 bags have been obtained, an enormous increase over the old first-class average.*

From the evidence contained in Brown's table and from our own observations of crops it becomes apparent that we are dealing with grave possibilities which should receive the most earnest attention of all classes of cultivators. In the author's opinion the greatest progress will be attained by those who cultivate selected standard varieties which have been proved good croppers, securing such by the means indicated in preceding pages.

Sir Daniel Morris, writing in 1882, says:

> At the sixth and on their ninth years the cacao-tree should be in fair bearing, but they seldom reach their prime before their twelfth or fifteenth year. After this period, where the trees have been carefully established and well cultivated, a cacao estate is a comparatively permanent investment, and it may be expected to continue in bearing and yield remunerative returns for some fifty, eighty, or a hundred years. In fact, if old and exhausted trees are regularly and systematically replaced or "supplied" there is practically no limit to the duration of a cacao estate.

This statement is quite accurate, as there are many such estates in Trinidad and other parts of the West Indies, although a few theorists may dispute the point on technical grounds, which deny permanent fertility. The fact, however, should not be overlooked that many such estates, with liberal treatment in the supply of suitable manures, may be made to show a much larger

* *See* "Possible Yield of Cacao," in Bulletin, Agricultural Information Trinidad, July 1909, p. 65.

return than if left entirely to the natural resources of the soil and its natural increment of plant food.

Yield clearly depends, first, upon the kind of tree cultivated; secondly, upon the richness of the soil or the natural amount of plant food available; thirdly, upon the artificial supply which may be applied; and last, but by no means least, upon the amount of skill which is brought to bear by the cultivator in maintaining conditions suitable for the production of large crops.

Taking the crops of to-day in Trinidad we have:

5 bags	(a scant crop)	= 825 lb. per 1000	= 0·82 lb. per tree.
10 ,,	(average crop)	= 1650 ,, ,,	= 1·65 ,, ,,
15 ,,	(good crop)	= 2475 ,, ,,	= 2·47 ,, ,,
*20 ,,	(superior crop)	= 3300 ,, ,,	= 3·30 ,, ,,

For comparison 1000 trees at 15 lb. per tree shows 15,000 lb., and in that report we find a sure margin for improved production.

It may be said that such views are optimistic, and plenty of pessimists will be found to cry *non possumus!* it is not possible! But so said our forefathers of the steam engine and the flying machine—yet they appeared; but that we are in advance with evidence on our own point as to the possibility of increasing a crop has been shown by the actual yield of trees. There ought, therefore, to be full confidence that if the question is taken up and carried on on the proper lines, enormous and hitherto unheard of returns will be secured.

There are diverse opinions as to methods to be adopted for securing this result, among which are (1) the abolition of the use of shade; (2) the adoption of seminal selection; both of which have been recently advocated (1910) in Trinidad. These points and others, more advanced, have been fully discussed in preceding pages, but our suggestions may be again stated briefly:

(1) The selection and standardisation of certain types of cacao, and the propagation of these by budding or grafting, as in fruit orchards.

* One hears, but one awaits further evidence regarding, reports of twenty-five and thirty bags.

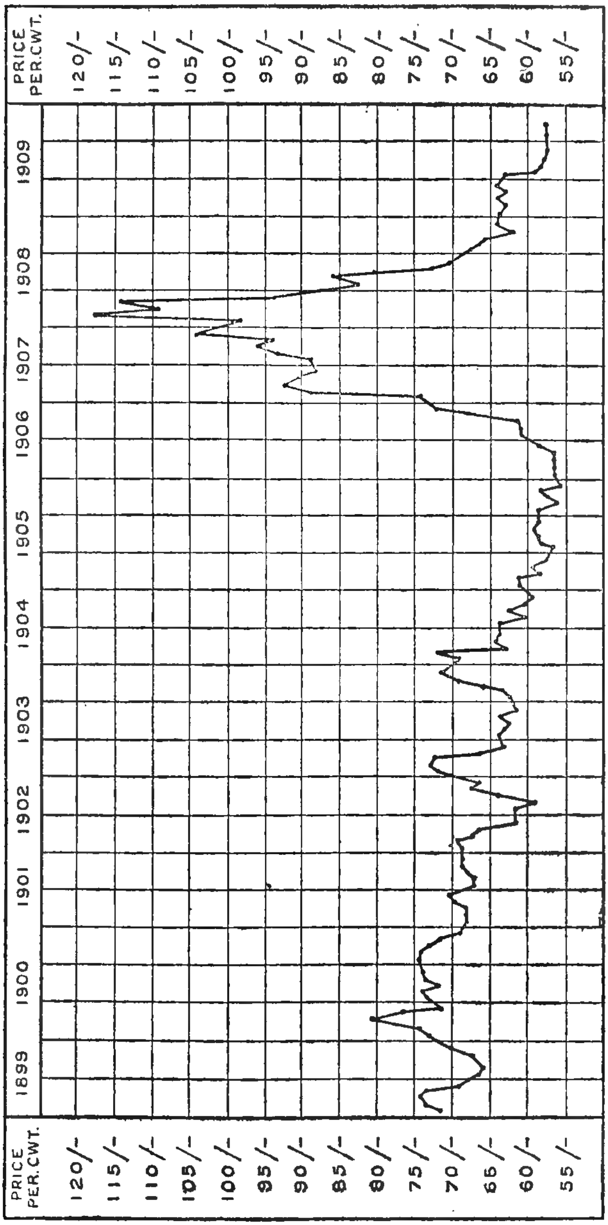

FIG. 58.—The Market Prices of Cacao 1899-1909

(2) The abandonment of propagation by seed, on account of the excessive variation that occurs under any method of seminal or seed selection, *i.e.* the trees cannot be made to come true from seed.

(3) Better systems of cultivation and preparation.

It is not indicated that a yield of 15 lb. per tree will be obtained generally on estates, but that an increase of 100 or 150 per cent. may be obtained over the best yields of to-day if the proper methods are followed. The writer is fully satisfied of the possibilities for improvement shown by actual statistics of ascertained yield, which, in his view, justify the hope that under improved cultivation the yield of the cacao-tree may be increased to an extent hitherto deemed quite impossible.

It appears clear that if there are trees showing the same yields as found on the Brown estate, of which there is no doubt, it is merely a question of obtaining numbers of them in order to increase the yield to an extent which would double or treble the income of estates, after allowing for bad spots in lands, diseases, and all other factors which tend to reduce crops.

Calculations of the value of a crop can be easily made by readers taking Trinidad prices on the basis of a table recently furnished by Messrs. G. R. Alston and Co. to the Local Department of Agriculture:

Trinidad Local Prices for Cacao

	Per fanega of 110 lb. and Dollar at 4*s.* 2*d.*
1892	$13·00 to $13·50
1893	14·00 ,, 14·50
1894	12·75 ,, 11·75
1895	11·75 ,, 10·00
1896	10·00 ,, 9·00
1897	9·00 ,, 16·00
1898	16·00 ,, 14·50
1899	14·50 ,, 15·25
1900	16·00 ,, 14·00
1901	14·00 ,, 13·50
1902	13·50 ,, 12·00
1903	12·00 ,, 13·00
1904	13·00 ,, 11·75
1905	11·75 ,, 11·00

	Per fanega of 110 lb. and Dollar at 4*s.* 2*d.*
1906	\$10·00 to \$19·00
1907	19·00 „ 25·50
1908	18·50 „ 12·00
1909	12·00 „ 11·00
1910	11·25 „ 12·10

The diagrams on pages 226 and 229 representing the exports of cacao from 1900 to March 31, 1909, and market prices from 1899 to 1909, were prepared under the direction of the Department of Agriculture for Trinidad, and were exhibited for public reference at the Agricultural Show in Port of Spain, the capital of Trinidad, in February 1910. These diagrams serve to show the general progress of the cacao industry in Trinidad and the ruling prices.

The cost of harvest and curing is estimated to average some \$2·40 or 10*s*. per bag of 165 lb., which is the general figure allowed by the management on Trinidad estates to overseers in charge of the work, to cover expenses. Picking and hauling are done by contract in most cases. It appears, however, doubtful economy to allow picking to be hastened by contract work, as the result will assuredly be damage to the trees through careless and hasty methods.

CHAPTER XIX

THE LAND AVAILABLE, AND THE VALUE OF A CACAO ESTATE

FROM a return made by the Crown Lands Department of Trinidad, it appears that the total amount of unalienated lands in the colony on Mrach 31st, was 538,669 acres, much of which is mountain and swamp land unsuitable for the growth of cacao. There are, however, many thousand acres of good land still available for this kind of cultivation. The area in cacao is not definitely known, but, estimated by the export returns, it may be approximately ascertained from the statistics already given.

The present price of Crown Lands in Trinidad is £2 10*s*. per acre, most in original forest, and, for the greater part, somewhat distant from the centres of population, therefore difficult of access, and growing more so year by year.

In the usual course of business, however, there are large and small private estates constantly upon the market, the price of which varies, according to locality, the quality of the land and facilities of transport.

The value of a cacao estate is usually estimated at per 1000 trees, and not at per acre. The price varies from 60 cents, or 2*s*. 6*d*. per tree in one district, to $2, or 8*s*. 4*d*. in another.

The most satisfactory method of valuation is to count the number of trees upon the ground, grading them as follows: No. 1. Full-bearing trees. No. 2. Half-bearing trees. No. 3. Quarter-bearing trees. The valuer then fixes price per tree according to his estimation of their condition, the class of cacao grown, the position of the estate, the facilities for transport, the labour supply, and the number

and condition of the buildings upon it, &c. If the price is fixed at $1 per tree, then half-trees would be rated at 50 cents, and quarter-trees at 25 cents, and these totals give the value of the estate.

Another method is to find the average number of bags of 165 lb., each produced by an estate during at least five previous years, and to multiply this number by 100 to 150 as a factor, according to locality, facility for transport condition and number of buildings, &c., when the result will give the value in dollars, low condition standing at 100, and prime condition at 150, according to valuator's judgment. An estate giving 200 bags on an average of previous five years, the factor fixed at 140, would be valued at $28,000, or £5,833 6*s.* 8*d.*

It will be seen that in both methods the procedure is empirical, and resting entirely upon the experience of the valuer, in his estimation of field conditions. The acreage is generally known, and plans of the lands are generally available for the inspection of intending purchasers and their valuers. If any uncultivated land adjoins, which might be used for extending cultivation, this will generally be separately bargained for, or the rate of purchase raised on the cultivated portion to cover it. In making an important purchase buyers should insist upon an accurate count of trees, with detailed reports on their quality, condition and age, &c., &c.

The employment of a licensed surveyor of lands is a matter also in the hands of the purchaser. There are officers available, whose services can readily be obtained and whose work is of a very reliable character, as they are only admitted to practice after a strict examination carried out by the Government Survey Office. Previous surveys may, in general, be relied upon, but where the price is large, and the estate an old one, it is as well that the buyer should have the boundaries checked, in case of encroachment having occurred.

The working expenses of a plantation may be calculated at £3 to £5 per acre annually, more or less, according to

circumstances, facilities for obtaining labour, easy transit of produce, &c., &c.

It is calculated that an estate can be established by the contract system at a cost of about £12 to £15 per acre, exclusive of buildings.

The buildings required on a cacao estate are few. Where the proprietor is resident there should be a comfortable residence, and therefore the expenditure under this head cannot be laid down, but must be left to the individual taste of the planter and the extent of his means, as must also be the accommodation for overseers. In general the proper housing of the staff is conducive to economy. A man when he is comfortable will do more for an employer than when he has to shift for himself in the way of house, garden, &c.

The most important buildings on a cacao estate are the drying houses and sweating boxes. These are generally built all in one, the sweating boxes being placed under the drying floors, but sometimes they are separated, and we believe that this latter course is the best, as during the process of fermentation much moisture is given off by the bean, and this cannot be conducive to quick drying on the floors above, or to the sanitary condition of the building.

The cost of drying houses for an estate of 300 acres would probably be some £200 to £250 each, or perhaps more, if substantial buildings are to be erected and artificial drying resorted to, and several of these would be required as an estate developed. A single drying house will be sufficient to commence with on an estate made from virgin forest, as the crop will be gradually increasing from year to year, and the necessary drying space should be extended so as to keep pace with the number of trees coming into bearing, but it is always better to have ample drying space, for much is gained by such a policy, as there is a liability to spoil produce when there is not sufficient room in the drying houses.

It is generally considered that eighty square feet of drying surface is sufficient space for drying the produce of 1000

trees, taking the crop of the year from beginning to end. If the planter therefore can find out what it will cost him to provide this area he can easily estimate for larger surfaces, the cost of building largely depending upon the district in which the plantation is situated.

Next to the drying house a good storeroom and office should be provided and a proper range of labourers' barracks may be required where labour has to be brought from a distance.

It will be found much better to attach labour to an estate by the allowance of house room, provision ground or other privilege, than to employ casual labour as it presents itself, as there is much more interest taken in the work when the labourer in a measure "belongs to the estate," and looks upon it as his home. Such dwellings should stand on a well-drained site, convenient, but not *too near*, to headquarters of manager or owner.

Skilled labour is highly requisite on a cacao estate, *i.e.* the labourer must be accustomed to the work, and the higher the class of labourer employed the better will the estate be worked. Such labour is, however, not always obtainable, but it is certainly the best when it can be had. We are not here speaking of the manager, foreman, or ganger, but of the field hands for the purpose of carrying on the general work of the plantation. With managers and foremen generally, it is evidently to the interest of the proprietor to employ only those who take an intelligent interest in the work they have to carry out, and who take pride in preparing a quality of produce which shall always bear the highest stamp. With such men careful experiments may be carried on which will lead to improvement and economy when compared with the methods now in use.

The cost of labour is an item always inquired about by a newcomer, and at times not easily answered, but he will understand that this must vary with the district, and only a general idea can be given in a work of this kind. Wages on a cacao estate vary, according to the work performed by the labourer, from 25 cents to 60 cents per day. Much

of the work is done by task, a system which is much preferred by the labourer.

A supply of labour of a suitable character is provided in Trinidad and some other colonies by the introduction of East Indians through Government Immigration Departments. These are mostly intelligent and quiet people, and, when well trained, make very reliable workmen. This class of labour can be obtained on making timely application and proper agreement with the authorities, who, as a rule, make importations annually, women and children included.

The East Indian has always an opportunity to return to his native country, but many remain and make excellent citizens. The amount of money carried away by returning immigrants is strong evidence of the possibility of thrifty and industrious hands effecting a considerable rise in their condition of life, by working well under this system. A very large number settle in the colony in which they are indentured, and the evidence of their progress in life is apparent even to the casual observer.

CHAPTER XX

PRODUCTION OF CACAO

There are several well-known publications which collect statistics affording approximate records of the crops of various producing countries, and " give one a general idea of the cacao crops exported."

For the " general idea " we make use of the well-known statistical issue known as the *Gordian*, to point out that the production of cacao appears to be on the increase. In 1904 the largest grower appears to have been Ecuador, followed in succession by Brazil, San Thomé, Trinidad, San Domingo, and Venezuela, which may for our purpose be termed first-class producers. Grenada follows at the head of the second class, with not quite half the production of Venezuela, and the remainder show a gradually decreasing output. The highest total outputs for 1904 were in round numbers :

Ecuador . .	28,000 tons.	San Thomé .	20,000 tons
Brazil . .	23,000 ,,	Trinidad .	18,000 ,,

The total output of the British West Indies appears as 27,729 tons. If Venezuela and Surinam are included under foreign West Indies the total output for the West Indian centre amounts to 60,985 tons, which is 41·6 per cent. of the world's crop for the year in question, the Trinidad crop being the largest item.

Export of Trinidad Cacao

Year.	Quantity.	Value.
1891	16,188,493 lb.	£439,786
1892	25,041,635 ,,	648,103
1893	19,106,553 ,,	535,055
1894	21,608,384 ,,	509,808
1895	29,458,813 ,,	620,634

Year.	Quantity.	Value.
1896	23,481,848 lb.	£452,141
1897	23,840,665 „	532,123
1898	24,340,960 „	705,956
1899	29,225,504 „	778,679
1900	30,383,808 „	852,568
*1901–2.	30,154,768 „	847,416
*1902–3.	37,585,184 „	907,531
*1903–4.	36,154,048 „	897,033
*1904–5.	40,753,776 „	887,670
*1905–6.	48,416,256 „	1,041,109
*1906–7.	27,570,928 „	802,073
*1907–8.	49,730,576 „	1,786,386
*1908–9.	49,137,088 „	1,152,285

NOTE.—These statistics are taken from Customs' returns. In the years marked by asterisk (*) the official year ends March 31. From 1891 to 1900 the years are taken from January to December.

It will be observed that the increase in the rate of production has been rapid, having practically trebled itself in eighteen years.

In some measure this increase is due to better cultivation, but the major reason is the large increase of the area under cultivation.

The world's consumption, taken from a table published by Wright, amounted in 1904 to 146,565 tons, and of this 60,985 tons were supplied by the West Indian centre. In 1904, therefore, Trinidad supplied 12·67 per cent. of the world's crop, her output for 1904, taken from the table mentioned, being 18,574 tons.

As will be noted in the table, there is a large amount of variation in the annual crop. This chiefly arises from the occurrence of bad seasons, and seasons giving early and late crops, which may run into the following year or leave a part of their crop in the preceding.

Taking the mean of the last two years (1907–8 and 1908–9) in the above table and reducing the pounds to tons, we find the annual yield in Trinidad was over 22,000 tons, an increase of over 4000 tons annually since 1904, of a value of nearly one and a half million pounds sterling, a fact which gives Trinidad the lead in cacao cultivation throughout the West Indies and Central America, and unless Brazil and Ecuador have progressed at the same rate,

the colony has largely increased its standing among the first-class producing countries.

The exact acreage of land under cacao in Trinidad is unknown, as no proper facilities at present exist for ascertaining the amount of land under cultivation, and therefore only estimates are available, which do not appear to be of a character to allow of accurate deductions.

If, however, the export of cacao from the island is taken for the last two years in the above table we find that it averages a total of 49,433,832 lb. In 1910 the actual exports were 57,839,074 lb.

If we take the average number of trees per acre at 200, and the yield per tree at 1·65 lb., we are able to show from these factors that the cacao area is some 149,799 acres, and the yield per acre some 330 lb.

In a paper by the Hon. Carl de Verteuil, read at the Agricultural Conference, Barbados, 1907, it is stated that a Government Committee reported the area under cacao as "unknown," and drew attention to the entire absence of statistics relating to agriculture, and Mr. De Verteuil follows this by recording that in the Blue Book for 1904–5 the land under cacao is "given as 190,000 acres." From other statistics, based on estimates only, Mr. De Verteuil deduces that the average yield per acre "for 1904–5 (a good year) and 1905–6 (a poor year) is 3¼ bags per acre, the bag being equal to 1¼ cwt., or 140 lb., giving 452·5 lb. per acre, which is considerably in excess of the estimated average yield of ten bags of 165 lb. per 1000 trees" (*West Indian Bulletin*, vol. viii., p. 141, 1907).

Previous pages show that the limit of yield is a very elastic one, and that Mr. De Verteuil's estimate is not high by any means, nor does it reach by a considerable distance the actual limit of yield per tree, which is proved by Brown's table (*Trinidad Bulletin*, vol. viii., p. 68).

The relative production of cacao is tabulated in the *Gordian* for the undermentioned countries for the year 1910 as follows, leaving out fractions of 100,000 lb.:

	Lb.
(1) Brazil	62,200,000
(2) Ecuador	84,600,000
(3) San Thomé	80,500,000
(4) Trinidad	67,500,000
(5) Dominican Republic	36,600,000
(6) Venezuela.	35,100,000
(7) British West Africa	55,200,000
(8) Grenada	11,500,000
(9) Hayti	4,800,000
(10) Ceylon	7,800,000
(11) German Colonies	10,500,000
(12) Jamaica	3,900,000
(13) Dutch East Indies	5,500,000
(14) Fernando Po (Spanish)	4,800,000
(15) Surinam	4,500,000
(16) French Colonies	3,300,000
(17) Cuba	2,700,000
(18) St. Lucia	1,400,000
(19) Belgian Congo	1,900,000
(20) Dominica	1,200,000
(21) Costa Rica	700,000
Various other places	2,600,000
	478,800,000

the approximate grand total being some 478,800,000 lb., or 213,750 tons.

Production has shown generally a steady increase since 1902, but in Surinam and Cuba there has been a decrease due to well-known causes. British West Africa has made enormous strides, the increase of crop during the years 1902 to 1908 inclusive being nearly 700 per cent.

The production in British colonies ranks as follows, taking data in million pounds without fractions :

	Lbs.
Trinidad	57,500,000
British West Africa	55,200,000
Grenada	11,500,000
Ceylon	7,800,000
Jamaica	3,900,000
St. Lucia	1,400,000
Dominica	1,200,000
Total British Possessions	138,500,000

Recent returns show that West Africa is again increasing her yield at a greater rate than in previous years. This

would appear to be a mandate to the West Indian cultivators to " keep their house in order," in order to be able to meet the apparently rapidly approaching period of over-production.

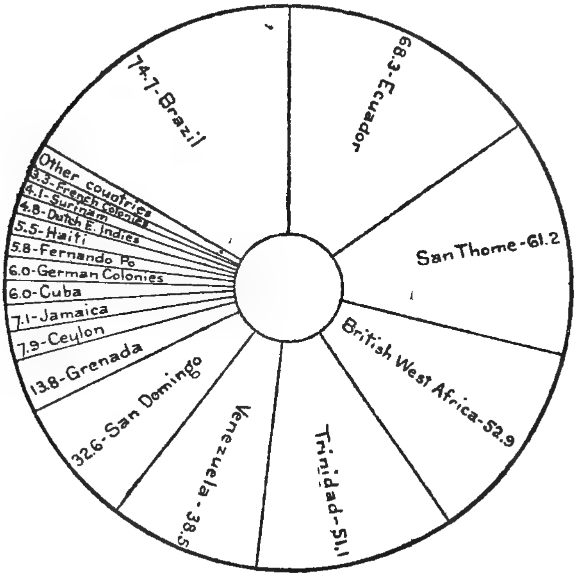

FIG. 59.—The World's Cacao Production.
Total 452,000,000 lb. The quantities by countries are given in millions of pounds.

Grenada shows a small decrease in the same period, and Ceylon a small increase. Jamaica has nearly doubled her output in the records of the seven years, while St. Lucia and Dominica have remained practically stationary.

Of the world's crop the British possessions afford practically one-fourth, and Trinidad alone (approximately) one-ninth of the supply.

In an excellent article reproduced in *The West India Committee Circular* the world's production is ably discussed and charted by Mr. John J. Macfarlane in the *Tea and Coffee Journal,* which we reproduce in a somewhat condensed form.

It was Humboldt who estimated that in 1806 the entire European consumption of cacao only amounted to 20,000,000 lb. annually, of which nearly one half was consumed in Spain. There has been, however, an enormous increase in the production and consumption since that time, more especially in the last fifteen years. In 1894 the world's production amounted to about 142,000,000 lb. By 1903 this quantity had doubled, and in 1909 it was 452,000,000 lb., or $3\frac{1}{5}$ times as much as in 1894. The chart of production of cacao on the preceding page gives in millions of pounds the quantities produced by the leading countries in 1909. There is no way of ascertaining the amount consumed locally in producing countries, and, therefore, these quantities represent the amount exported, or practically the quantities of cacao entering into international trade.

The consumption of cacao has also increased rapidly, until in 1909 it reached 427,000,000 lb. The stock on hand at the end of 1909 amounted to 195,000,000 lb., against 173,000,000 lb. at the end of 1908, and 100,000,000 lb. at the end of 1907, showing that while consumption is increasing rapidly it has not kept pace with the increased production of the last two years.

In some of the newly developed cacao-producing regions new plantations are being started annually, and, as these come into bearing, the quantities produced will continue to increase, so that it is an important question for both planters and consumers as to whether future consumption will keep pace with the probably enormous increase in production.

From the chart of consumption, which is given on page 244, it is readily seen that the United States leads all other nations in the imports of cacao for consumption. In the calendar year 1909 the United States imported 23,000,000 lb. more than in 1908. During the fiscal year ending June 30, 1909, the latest for which complete statistics are available, the United States imported 129,854,000 lb. The British West Indies led in imports into that country,

having furnished 85,000,000 lb., mostly from Trinidad. Santo Domingo supplied 15,000,000 lb.; Cuba 2,000,000 lb., and Haiti 1,000,000 lb.

The imports from South America were: Ecuador, 16,000,000 lb.; Brazil, 14,000,000 lb.; Venezuela, 6,000,000 lb., and Dutch Guiana, 4,000,000 lb., with smaller amounts from other countries. There were no direct importations from Africa, their products reaching here *viâ* European countries.

Portugal supplied 22,000,000 lb., which was entirely the product of St. Thomé and Principe. Germany sent 5,000,000 lb.; Great Britain, 4,000,000 lb.; France, 1,000,000 lb., and Holland, 1,000,000 lb., all being re-exports of cacao from Africa or America.

Nearly all the European countries increased their imports in 1909. Those of Germany increased 14,000,000 lb.; of Great Britain, 7,000,000 lb.; France, nearly 4,000,000 lb.; Holland, 8,000,000 lb.; Switzerland, nearly 2,000,000 lb.; Spain, which a hundred years ago consumed more cacao than all the rest of Europe, is now far behind in the list of cacao-consuming nations and has made no increase in imports recently.

The following table gives, in millions of dollars, the average consumption for five-year periods of the leading consuming countries and their percentage of increase:

	Average, 1894–1898	Average, 1904–1908	Actual Increase.	Percentage of Increase.
United States	23·1	81·5	58·4	252
Germany	27·1	72·5	45·4	167
Great Britain	25·8	45·1	19·3	75
France	34·8	48·5	13·7	39
Holland	14·7	27·3	12·3	85
Spain	13·2	13·0	·2	—
Switzerland	5·5	13·6	8·1	147

In the United States the increase in both quantity and percentage of increase has been greater than in any other country.

The growing popularity of cacao and its products in the United States is seen in the comparison of its imports with those of coffee and tea. Cacao imports have grown

from 18,000,000 lb. in 1890 to 129,000,000 lb. in 1909; coffee imports, from 499,000,000 lb. in 1890 to 1,049,000,000 lb. in 1909, and tea imports, from 84,000,000 lb. in 1890 to 114,000,000 lb. in 1909. Thus cacao importations have in-

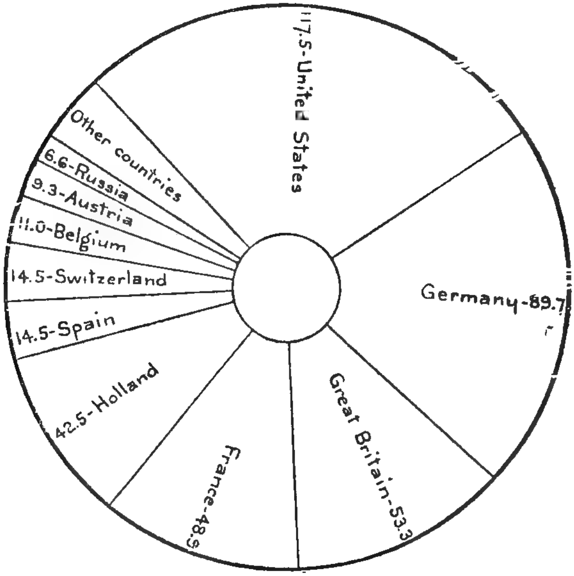

FIG. 60.—The World's Consumption of Cacao
Total, 427,000,000 lb. The quantities by countries are given in millions of pounds.

creased seven times during the period under consideration, while those of coffee have a little more than doubled, and those of tea have increased 40 per cent. In value, the imports of cacao have grown from 2·3 million dollars in 1890 to 14·8 million in 1909, while those of coffee are practically unchanged, being 78·2 million dollars in 1890 and 79·1 million in 1909, and those of tea have increased about 50 per cent., being 12·3 million dollars in 1890 and 18·5 million in 1909.

Another interesting fact with reference to this more rapid growth in the imports of cacao is that it has occurred in

the face of a greater advance in price of that article than has occurred in either tea or coffee. The average value per pound of the crude cacao imported in 1890 was 12·7 cents, and in 1897, 14·5 cents; that of tea, 15 cents in 1890 and 16·1 cents in 1907; while that of coffee shows a marked fall, having been 16 cents in 1890 and 7·9 cents in 1907.

It has only been during the last fifteen years that the world has recognised the importance of cacao and its products as a food. The people of the United States were the last to do so, but, as already seen, they now consume more than any other nation.

Cacao, coffee, and tea are somewhat similar products, being used largely as beverages. There has not been as large a percentage of increase in the consumption of coffee and tea as there has been of cacao. This is true, not only in the United States, but also in other leading countries, as can be seen from the following table, in which the increased consumption of these three articles during 1909 over that of 1896 is given in quantities and in millions of pounds:

		Cacao.	Increase, Per cent.	Coffee.	Increase, Per cent.	Tea.	Increase, Per cent.
United States .	1896	22·9	—	575·4	—	93·0	—
	1909	117·7	414	903·8	57	99·2	6.6
Germany . .	1896	26·8	—	286·6	—	5·7	—
	1909	89·5	333	470·5	64	10·9	91
Great Britain .	1896	26·2	—	26·6	—	225·6	—
	1909	53·3	100	30·2	13	282·1	25
France . .	1896	33·5	—	159·3	—	1·6	—
	1909	51·1	52	235·1	46	2·6	6
Holland . .	1896	15·8	—	82·2	—	6·5	—
	1909	42·5	168	104·9	27	10·2	51

This table includes the largest coffee-consuming country, the United States, and the largest tea-consuming country, Great Britain. In every case the percentage of increase of the consumption of cacao exceeds that of either tea or coffee, and, with the exception of France, is many times greater.

Of the 89,000,000 lb. imported by Germany in 1909, 22,000,000 lb. came from British West Africa; 19,000,000

lb. from St. Thomé and Principe; 15,000,000 lb. from Brazil; 11,000,000 lb. from Ecuador; 7,000,000 lb. from San Domingo; 5,000,000 lb. from the British West Indies; 4,000,000 lb. from Venezuela, and 2,500,000 lb. from the Cameroons in German Africa. Great Britain imported 77,000,000 lb. in 1909, the largest amount ever imported. It retained 53,000,000 lb. for home consumption, re-exported 14,000,000 lb., and added 10,000,000 lb. to the stock on hand.

France imported 116,000,000 lb., but retained 49,000,000 lb., or less than one half, for home consumption. The principal sources of supply are the British West Indies, 12,000,000 lb.; Brazil, 10,000,000 lb.; Venezuela, 9,000,000 lb.; the French Antilles, 3,000,000 lb.

A large part of the imports into Holland are from Germany and France, although most of the product of the Dutch East Indies is sent to Holland.

CHAPTER XXI

THE FOOD VALUE AND MANUFACTURE OF CACAO

THE averages of many analyses of the cacao bean were reduced some years ago by P. L. Simmonds, author of a work on "Tropical Agriculture," with the remark that the results were "not very flattering to chemical science." This was probably due to the large differences found in the various samples, a fact which is discussed by the present writer under the head of "The Chemistry of Cacao," in the hope that measures will be taken to see that further inquiries may be carried on under conditions which will tend to substantially contribute to our knowledge of the subject.

Professor Harrison's work standing as the best authority of the day, Simmonds' table is here quoted in order that any desired comparisons may be made:

Cacao butter	50
Albuminoids	20
Starch	13
Salts	4
Theobromine	2
Miscellaneous	11
	100

In "The Food of the Gods," by Brandon Head (1903), p. 19, a chemical analysis of cacao "nibs" is given to show the value of "cocoa essence," a trade product of one of our largest manufacturers, which appears to compare rather closely with Simmonds' average.

	Cacao nibs.	Cacao essence.
Cacao butter	50 parts	30 parts
Albuminoid substances	16 ,,	22 ,,
Carbo-hydrates (sugar, starch, and digestible cellulose)	21 ,,	30 ,,
Theobromine	1·5 ,,	2 ,,
Salts	3·5 ,,	5 ,,
Other constituents	8 ,,	11 ,,
	100·0	100·0

Professor Church in "Food," gives the following analysis:

Water	5·0
Albuminoids	17·0
Fat	51·0
Theobromine	1·5
Cacao red	3·0
Gum	10·9
Cellulose	8·0
Minerals	3·6
	100·0

The Professor concludes that "Theobromine is the active principle of cacao, and that taste and aroma are due to an essential oil, and to tannin," and deems cacao a milder and less stimulating beverage than either tea or coffee. He also mentions four forms of preparation, in which starch, flour, sugar, vanilla, bitter almonds, cinnamon, and other spices or flavouring substances are added to cacao, in "soluble cocoa," "chocolate," "flake or rock cocoa," and "pressed cocoa," for the making of which a portion of the original fat of the cacao bean has to be removed. He says:

Most of the cacao consumed in Europe is prepared for use by admixture with other substances or by removing part of the fat or "cacao butter." Cacao-nibs, if simply ground, would yield a rich but heavy food but not a beverage. It may indeed be shown that 100 parts of cacao-nibs contain heat-givers equivalent to 132 parts of starch, while the flesh-formers present amount to no less than 17 parts, the ratio of the latter being as 1 to 8. One pound of cacao-nibs might, in fact, produce as much as 2¾ oz. of the dry nitrogenous substance of muscle.

This shows that one pound of cacao-nibs is more than equal in flesh-forming constituents to one pound of lean mutton chop, which is estimated to contain but 2 oz. of the dry nitrogenous substance of muscle or flesh. But we cannot eat or drink a pound of cacao-nibs at any one time,

and it is seldom that more than $\frac{1}{2}$ oz. is used for a breakfast cupful, and even to this is added a certain proportion of milk and sugar; the value of the milk as a food constituent being as $\frac{3}{4}$ oz. of the dry nitrogenous substance of muscle and flesh to the pound. If it were consumed as "nibs" it would certainly be a "heavy food," as it appears to contain 50 per cent. of fat, and 17 per cent. of albuminoids, besides other constituents. No one eats it in the form of "nibs," however, but we consume it in small quantities in solution, and therefore, when we take of prepared cacao a part equal to $\frac{1}{32}$ part of a pound, and add, say, 4 oz. boiling water and 4 oz. milk, we have, according to the Professor's analysis, the sum of $1\frac{3}{8}$ drachms + 3 drachms or a total of $4\frac{3}{8}$ drachms of flesh-forming constituents in a cup of cacao made from the ground nibs *unadulterated,* of which 3 drachms are supplied by the added milk, or a total value of ($\frac{1}{10}$) one-tenth of a pound of mutton chop. The proportion of nutriment which is contained in a cup of cacao made from the various preparations we are not able to gather, but should estimate it at a very much lower figure, notwithstanding the many advertisements claiming high value.

That cacao-nibs, simply roasted and ground, will yield a beverage of excellent quality when properly prepared there can be no doubt, though perhaps not one calculated to suit all tastes; but once the palate is "educated" to the flavour, it is preferred to any of the adulterated forms or preparations. In samples of cacao or "cocoa" made by the best makers, no less than 60 per cent. of sugar has been found. This large amount of sugar is accounted for by the fact that without this addition it does not sell.

Not a little prejudice exists as to the digestibility and indigestibility of cacao fat, and this prejudice is taken advantage of by some manufacturers in making their preparations. It is somewhat curious to note, however, that some of the fat extracted from the preparation intended for use as a beverage is used in the preparation of confectionery, such as "chocolate creams," when no

questions whatever arise as to its indigestibility. Many indeed who object to a certain amount of fat with their breakfast cacao, use ten times the amount of quite as indigestible a fat, in the form of butter, without a thought of indigestion. The value of chocolate creams, chocolate stick, and other "*bon-bons*" as a food may be estimated from the analyses. They contain from 12 to 40 per cent. of cacao which has a large percentage of fat, some starches, and some albuminoids, and these, added to the food value of 60 per cent. of sugar will give the total value, which will be found over-estimated in the majority of cases, both by sellers and consumers. If the public could be persuaded to demand pure cacao, adding the sugar themselves, they would be better served.

In Central America, and in most cacao-growing countries, the bean is manufactured for local consumption into the form commonly known as "chocolate," made into rolls, cakes, or balls convenient for use. In Central America, especially in Nicaragua and lower Mexico, the produce of the cacao-tree is used for the early morning meal by rich and poor. It is, however, not consumed as a beverage, but as a pap, or porridge, with the admixture of a preparation of maize (Indian corn), which is specially prepared for the purpose. The process of making this food is simple in the extreme, as would naturally be expected where it has formed a portion of the food of the inhabitants from prehistoric times. The maize grains are soaked in water (to which a small quantity of lime has been added) for several hours, or until they are swollen almost to bursting, when the skin or cuticle of the grain is carefully removed. Corn prepared in a similar way is in common use in Trinidad for making "*Pastelles*," which are considered as delicious food, and much used among the better classes of the colony. The softened interiors are then mixed with an equal quantity of prepared "nibs" or cake chocolate, and ground into a fine paste on a native mill or stone, which is well adapted to the purpose. A drawing is shown on next page of one seen by the writer (Fig. 61), of simple construction,

and cut from solid stone found in the country, which has a " grit " peculiarly suited for the purpose. The roller or grinding stone is worked by a pushing or sliding motion by the operator sitting on the ground. Such stones are common throughout Central American cacao regions, where the writer saw them on sale in markets in 1893 and in

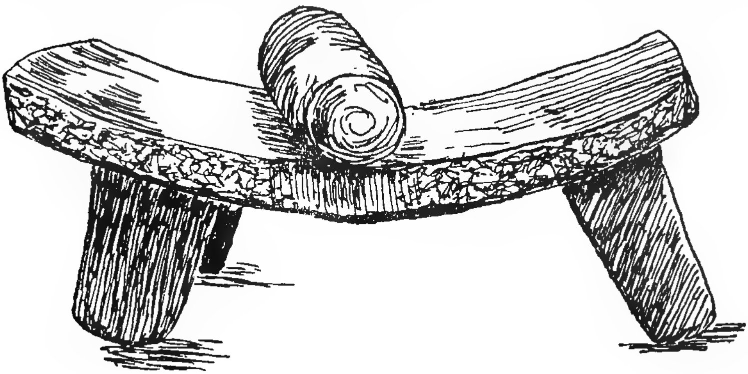

FIG. 61.—A Primitive Mill.

Mexico during 1910. When the corn and cacao are ground into a fine soft paste, this is boiled up with a sufficient quantity of water until it forms a thin porridge to which cow's milk and sugar in suitable quantities are added. It is then taken without further addition as the first meal of the day. The writer can fully testify to its sustaining power, having made journeys of some hours, without being unduly fatigued, after breakfasting upon *Testé,* as the preparation is called in Central America. The meal is generally served in carved calabashes in preference to the use of modern pottery, the woody or horny character of the cup being more pleasant to the lips than china or common ware. These cups are made from the shell of the fruit of the calabash-tree (*Cresentia cujete*), common in Central America and the West Indies.

The methods generally employed in Trinidad in manufacturing chocolate from the cacao bean are extremely simple, and the same in principle as those practised

throughout cacao-growing countries. The bean after being cured and dried in a manner fit for sale can be used at any time for manufacturing into chocolate. The first process is to roast the beans in a cylinder over a slow fire, until they assume a fine brown colour, but not to heat them to such a degree as to burn them, or to destroy the essential oil which they contain. Cacao beans once burnt or scorched can never make a cup of first-class chocolate. When browned sufficiently, the testa, cuticle, or skin, easily separates from the inner portion of the seed, and can be cracked off and fanned away as soon as the beans are cool enough to handle. Care should be taken to grind quickly after roasting, as once roasted, cacao if exposed soon loses flavour and aroma, and the manufactured article should always be kept in sealed or close-fitting receptacles.

The " nibs " are put upon a clean piece of free stone about two feet square, perfectly smooth, another piece of the same material, somewhat rounded, being used as a grinder. Rubbed for some little time and frequently turned with a small *spatula*, the beans are reduced to a paste, the fat they contain assisting the operation, but the grinding must be continued until the paste becomes perfectly smooth and even. If sweet chocolate is desired to be made, sugar should be added ; if " unsweetened " nothing more has to be done than to make the paste up into such sizes of blocks, rolls, or balls as may suit the fancy of the manufacturer or the convenience of the housewife. These balls, rolls, or blocks are then allowed to set or harden, which they will do in a few hours' time, after which they can be transported any distance. The operations of roasting and grinding should always be done in dry weather, as chocolate made in damp weather always keeps badly, the mould fungi attacking it more at such times. In fact, the chief difficulty in making local chocolate is the amount of moisture in the atmosphere. It is also essential that the day temperature should be high in order that the cacao butter may work more easily. It is the practice to employ sun heat to keep the paste soft while the grinding is going

on, in the same way as the temperature of a factory is maintained at a high point in all work-rooms where first-class manufacture is carried on. No adulteration is required, but still to suit some palates vanilla, nutmeg, cloves, cinnamon, and various spices may be added, but these combinations are, in our estimation, not equal to the flavour of virgin cacao, provided the volatile essential oil has not been destroyed during the process of roasting, during which process it appears to be developed.

A cup of delicious chocolate can be made in about three minutes in the following manner: Grate about ½ oz. of ball chocolate into an enamelled saucepan, adding sufficient boiling water to cover it; let it simmer for several minutes, then add sugar and hot milk to taste, and serve. If preferred, equal parts of milk and water may be used. The substance removed from the bean as fat by the more elaborate methods under which cacao is prepared is known as cacao-butter. This is a valuable concrete fat, melting at 100 ° F., which is expressed from the paste of the cacao bean by pressure while subject to steam or sun heat. On cooling it becomes an opaque, dry, chocolate-coloured substance, somewhat brittle, and shows a waxy fracture. The colouring is easily removed by filtering, while hot, through animal charcoal, when the fat becomes a clean white. It has a pleasant chocolate odour and a bland flavour, and is much used for pharmaceutical preparations. It is chiefly remarkable for having but little tendency to rancidity.

From the fact that clean fats have a remarkable affinity for the volatile or essential oils, it appears probable that a proportion of the aroma of chocolate may be lost by the removal of the cacao-butter, and this fact would account for the superiority of the flavour of that cacao in which the natural fat is all present, over that from which it has been removed. Usually the less the manufacturer adulterates a pure article the better are the prospects for the future of his business, but in cacao the converse appears to be the case. It is clear that more cacao would be sold if

the mixture of foreign substances could be disallowed, and the planter would in consequence reap a decided benefit from the greater demand.

If the local operator desires to make a cacao powder, he has to express a large proportion of the fat, which can readily be done in any common press with a little manipulation. Some years since the writer adapted a small cigar press for the purpose, which was seen by the author of "The Food of the Gods," and mentioned in his book, page 105. The cacao paste must be handled in a high temperature so that all the fat is in a melted state, and the apparatus must also be kept well warm. This can, in Trinidad, be effected by working in the sun, but in a temperate climate artificial heat is required and is employed in all the factories The paste is put between thin layers of cloth, neatly folded so as to prevent escape, and then placed layer upon layer in a strong press box worked either by simple screw or by hydraulic pressure. Sufficient of the fat can in this way be extracted to render the layers of paste dry, and formed into solid thin cakes. If these are now taken and rubbed through a fine sieve, a cacao powder will be produced (provided the beans are high class) in flavour quite equal to the finest brands upon the market, and unadulterated and pure. Sugar can always be added by the consumer, and no starch is necessary to make the article into palatable form, but starchy material may be added if it is desired to thicken the drinkable form.

Chocolate and cacao powder, pure and unadulterated, may well be called "the Food of the Gods," owing to the delicious flavour and exquisite aroma which they exhibit; but the lower qualities commonly sold and largely advertised are certainly not to be commended for public use. Even in the place where the bean is grown there are not wanting persons who will purchase the *passê*, or waste, of the drying floors and make it up for sale by itinerant vendors. Such material is often bought by visitors to the colony, who, in consequence, adopt ideas of quality which are contrary to the actual fact, and damage

the reputation of one of the principal exports of the colony.

In order to ascertain by personal experiment the character of samples of the cacao bean when worked up or manufactured for consumption, three separate samples were obtained from one of our largest dealers a year or two since. The samples were accurately weighed to 10 lb. each, were then roasted and ground, the fat extracted by an ordinary press, and the samples numbered 1 to 3:

No. 1. Venezuelan Fine Clayed	Valued at 14 cents per lb.
„ 2. Trinidad Fine Estates	„ 14½ „ „
„ 3. Trinidad Ordinary	„ 14 „ „

The following results were obtained:

No. 1. Venezuelan Fine Clayed Cacao, valued at 14c. per lb.

(1) Weight received		10 lb.
(2) Weight when roasted and cleaned		7·55 „
(3) Weight of husk		1·68 „
(4) Weight of dry cacao after fat was removed		5·50 „
(5) Weight of fat extracted from 7·55 lb.		1·23 „
(6) Loss during roasting and cleaning	·77 lb.	
(7) Loss during grinding and expression of fat	·82 „	
(8) Total loss in manufacture		1·59 „
10 lb. Dry cacao powder	55·0 per cent.	
10 lb. Fat *	12·3 „ „	
10 lb. Loss	32·7 „ „	
	100.0 per cent.	

Notes.—The loss is greater than it would be with larger quantities.
Comparing samples Nos. 2 and 3, it is seen that clay is to be estimated at about 1½ per cent.

No. 2. Trinidad "Fine Estates," valued at 14½c. per lb.

(1) Weight received		10 lb.
(2) Weight when roasted and cleaned		7·86 „
(3) Weight of husk		1·63 „
(4) Weight of cacao after removal of fat		5·60 „
(5) Weight of fat from 7.86 lb.		1·64 „
(6) Loss roasting and cleaning	·51 lb.	
(7) Loss during grinding and expression of fat	·62 „	
(8) Total loss		1·13 „
10 lb. Dry cacao powder	56·0 per cent.	
10 lb. Fat *	16·4 „ „	
10 lb. Loss	27·6 { 11·3 „ „	
10 lb. Husk	27·6 { 16·3 „ „	
	100 per cent.	

* Fat should be slightly more, owing to the absorption by the bags during extraction of first sample, possibly 13 per cent.

No. 3. TRINIDAD "ORDINARY" CACAO, 14C. PER LB.

(1)	Weight received		10 lb.
(2)	Weight when roasted and cleaned		7·80 „
(3)	Weight of husk		1·53 „
(4)	Weight of cacao after removal of fat		5·48 „
(5)	Weight of fat from 7·80 lb.		1·61 „
(6)	Loss during roasting and cleaning	·67 lb.	

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(3)	Weight of husk		1·53 „
(4)	Weight of cacao after removal of fat		5·48 „
(5)	Weight of fat from 7·80 lb.		1·61 „
(6)	Loss during roasting and cleaning	·67 lb.	
(7)	Loss during grinding and expressing fat	·71 „	
(8)	Total loss		1·38 „

10 lb.	Dry cacao powder		54·8 per cent.
	Fat *		16·1 „ „
	Loss	29·1	13·8 „ „
	Husk		15·3 „ „
			100 per cent.

The character of each sample was exhibited most distinctly by the colour and flavour of the dry powder, by the colour, character, and flavour of the fat, and by the aroma of both preparations.

The cacao powder made in this experiment proved to be an article which could be readily used in the same manner as the ordinary "cocoa" or "cocoa essence" of the manufacturers, and was a perfectly pure article. The character of each Cacao was well exhibited in the colour, flavour, and aroma, but it is probable that the quality of each sample might have been improved by a judicious blend with a milder or higher flavoured kind as required.

The Trinidad beans gave a powder with body, but the Venezuelan gave distinctly lighter produce, and there can be no doubt that the blending of various kinds will always afford merchandise of the highest quality. The article in itself was excellent and of fair flavour, but it would hardly suit the palate of those accustomed to finely blended productions of the best makers.

* Fat should be slightly more, owing to the absorption by the bags during extraction of first sample, possibly 13 per cent.

One of the facts to be noted is, that the mild flavoured and light-coloured Venezuelan cacao is rated at the same value as ordinary Trinidad, although it is evident it produces a cacao powder in some respects superior to "Ordinary" Trinidad cacao, balanced by the presence in the Trinidad samples of characters of equal value.

Brandon Head says, page 95: "The Trinidad bean is the largest and finest flavoured, and commands a higher price on the market than any other from the West Indies"; but the Central American or Nicaraguan is nearly double the size of the average Trinidad bean, and is valued at a higher price.

The value of cacao powder may be approximately estimated from these experiments, some 55 per cent. of it being produced from the total weight operated upon. In large factories this percentage would probably be lowered, owing to the better extraction of cacao butter. This fat sells at some 30 cents per lb., and the husks and skins are also marketable. Allowing a moderate figure for cost of manufacture, it is seen that pure cacao powder can be produced at reasonable rates from raw material costing from 1*s.* to 1*s.* 2*d.* per lb., and can be sold at prices leaving a good margin of profit.

It is to be noted that the mild-flavoured cacao (probably Venezuelan Criollo) of our experiment, No. 1, was priced at the same rate as "Trinidad Ordinary." It is quite evident, however, that it possessed a lighter colour, softer flavour, and less aroma, qualities which render it useful for blending with higher coloured and stronger flavoured varieties, the one being a complement to the other in the blending-room.

Similar differences would probably be found between Nicaraguan Criollo and Trinidad Calabacillo and other types, and perhaps in a more marked degree.

These variations in the interior character of the bean allow the manufacturer to manipulate the varieties in the blending-rooms, so as to produce the standard characters of the goods they so well maintain from year to year;

the proper colour, strength, aroma, and flavour being very largely dependent on the art of blending the varieties in correct proportions.

It is not proposed to attempt to deal with the details of manufacture as carried out in large establishments, as this would be outside of the scope of this work, which is intended principally for the guidance of those engaged in field cultivation. Some more able hand than that of the present writer will be necessary to deal with such a subject to good effect, especially as the desired information consists largely of trade secrets, which are controlled (and rightly so) by those who are interested by large investments in this industry.

But there are things of which some growers are unaware which may be suitably brought to their notice. For instance, many cultivators are unaware that the produce of Trinidad will not make—by itself—the standards of "cocoa powder," "chocolate" or "essence" which are familiar to the palate of the European or American consumer. Yet it is a fact. Trinidad does not stand alone in this respect, for in countries where a light red cacao is produced (interior colour) the produce will, or may, have to be blended with darker and more highly flavoured kinds in order to make the right blend, and yet the produce of both countries may have a name for high quality upon the markets. Cacao powder, chocolate, and various preparations can, of course, be made in all countries where cacao is grown, and such material would be considered excellent and highly palatable by those who are accustomed to its flavour, &c.; but for all that, the produce would not sell if put into competition with the various blends which have already found favour in the different markets; and it is this fact which greatly hinders the development of local factories, which have not and cannot obtain at reasonable rates the qualities necessary for blending. It would therefore appear to be to the interest of planters to supply, at least for local trade, many of those qualities which are used by the manufacturer, and this could be

done without much difficulty by importing and standardising the different strains and cultivating them entirely by themselves.

In 1905 Trinidad was represented at the Colonial Exhibition at the Crystal Palace, and it was suggested that "cocoa" and chocolate manufactured entirely of Trinidad material should be served in the Court allotted to the colony. It was, however, found impossible, after consultation with friendly manufacturers, to carry this into effect, for the reasons already mentioned.

Some years since the writer had the privilege of being allowed to visit two of the largest English factories. At these he was politely informed that there were certain sections to which none but employés were admitted, as they contained trade information which it was not desirable to place before the public, being private property only acquired after years of experiment and trial. At the same time, many interesting features were very kindly explained by a member of each firm, which proved of the greatest interest, and which no one could see without being impressed with the splendid organisation of these establishments, the completeness of the arrangements, the wonderful skill exhibited, the excellence of the materials used, and the extreme care taken to maintain in perfection systems of extreme cleanliness in all sections of the factories.

With regard to sugar as an adulterant with cacao, some do not admit that added sugar is an adulteration, while others term it *permissible*, or necessary adulteration. Manufacturers generally admit that in chocolates they use as much as 60 per cent., and declare that so long as the public demand it, they are bound to supply it in that form, and that the sweetest chocolate sells the best upon the market. In fact, they sell sugar flavoured and coloured with chocolate, rather than chocolate sweetened with sugar.

So long, therefore, as the public taste determines the matter, it is hopeless to expect pure preparations of cacao to be manufactured upon a large scale, as the factories

cannot be blamed for supplying a popular demand. It is, however, known that nearly all first-class makers do make pure preparations, which are purchased by those who prefer them, but the masses still buy the sweetened mixtures.

With the object of ascertaining the percentage of sugar in manufactured cake chocolate of the best makers, a sample was obtained which was being sold locally at three shillings per pound retail. In this pound 65 per cent. of sugar was found on polarising the sample. The public, therefore, is buying sugar at the rate of 36*d.* per pound or £28 per ton, while the sugar grower is glad if he can secure some £8 to £15 per ton. It is a curious thing that the general public have not as yet become alive to this fact, viz., that they are paying for sugar, when flavoured with chocolate, at a ridiculously high rate, or many times as much as the sugar planter realises per ton for the same article!

Brandon Head, in "The Food of the Gods," says: "Between Cocoa and Chocolate there are essential differences. Both are made from the 'cacao nib,' but whereas in 'Cocoa' the 'nibs' are ground separately and the 'butter' extracted, in 'chocolate' sugar and flavourings are added to the 'nib,' and all are ground together into a paste, the sugar absorbing all the superfluous butter. If good quality cacao is used, the butter contained in the 'nib' is all that is needful to incorporate sugar and 'nib' into one soft chocolate paste for grinding and moulding, but in commoner chocolates extra cocoa butter has to be added. It is a regrettable fact that some unprincipled makers are tempted to use cheaper vegetable fats as substitutes for the natural butter, but none of these are really palatable or satisfactory in use, and none of the leading British firms are guilty of making use of such adulterants, or the still more objectionable practice of grinding cocoa-shells and mixing them with their common chocolates."

On page 11 the same author refers to adulterants, and

writes: "In our own times it is unfortunately common to add potato starch, arrowroot, &c., to cocoa, and yet sell it by the name of the pure article. Such preparations thicken the cup, and are preferred by some under the mistaken impression that this is a sign of containing more nutriment instead of less. Although not so wholesome, there could be no objection to these additions so long as the preparations were not labelled 'cocoa,' and were sold at a lower price. Such adulteration is rendered possible by the presence in the bean of a large proportion of fatty matter or cocoa butter, which renders it too rich for most digestions. To overcome this difficulty one or other of two methods is available: (1) Lowering the percentage of fat by the addition of starch, sugar, &c.; or (2) removing a large proportion of the fat by some extractive process, the latter being in every respect preferred. . . . In order to avoid the expense and trouble consequent on the latter process, some manufacturers add alkali, by which means the free fatty acids are saponified, and the fat is held in the state of emulsion, thus giving the cocoa a false appearance of solubility. Another effect of the alkali is to impart to the beverage a much darker colour, from its action on the red colouring-matter of the cacao, this darkening being often taken unfortunately as indicative of increased strength." In fact, the consumer in such cases, while admiring the ring of froth around the edge of his cup should be undeceived by being told that such an appearance is due to the mixture of alkali and fat of cocoa. It is in reality nothing more than frothed "soap suds." That this statement is an accurate one can be proved by authoritative evidence after analysis of samples of this class.

On the use of the word "cocoa" there are many and divers opinions. Brandon Head, page 7, refers to it as "an unfortunate inversion of the name of the tree from which it is derived—the Cacao." And a footnote adds: "The *Cacao Theobroma*. There are several other varieties of cacao, but none of them produce the famous food."

In a "popular work," like that from which we are quoting, it is not expected that the author would adhere to strict botanical terminology, but we may take occasion to point out that the name as given in the footnote is written in error. It is not "Cacao Theobroma," but Theobroma Cacao, Theobroma being the *generic* and cacao the *specific* name. The note should have run: There are several other species of Theobroma which do not produce the famous food, *Theobroma bicolor* and *Theobroma angustifolia*, &c. The ancient name of the tree, that is to say, the Indian name, is "cacao" without doubt; but when it was named by the great Swedish botanist Linnæus, it received the name Theobroma as its generic appellation, and the name cacao was made its specific name. Theobroma is derived from the Greek words, *Theos*, "God," and *broma*, "food"; and Theobroma Cacao was the first known species of the genus.

The word "cocoa" is clearly of British origin and has caused no little confusion owing to the similarity of its sound to words which give name to entirely different products, such as coco-nut, coca, cocoes, &c. In England it is used in two senses: in the one to denote the raw material upon the markets, and in the other to distinguish the powdered form of the manufactured article from chocolate or solidified product of the bean. In Spanish countries where the bean is indigenous, the use of the word *Cacao* is universal. In botanical circles it is recognised as the true specific name, and it has been adopted in preference to cocoa by many, including the present writer, on account of many years' priority over the English word "cocoa." The pods of three other species have been depicted in previous pages; one of them, *Theobroma pentagona*, produces a high-class form of commercial cacao, while the other two, *T. bicolor* and *T. angustifolia*, do not yield the commercial article.

CHAPTER XXII

TRANSPORT OF CACAO PLANTS AND SEEDS

CACAO planters are often requisitioned for supplies of seeds and plants required in new countries where cultivation of this tree is being tried on a commercial scale. During the writer's official service in Trinidad numerous like applications were received and dealt with by the department under his charge. Cacao plants and seeds are difficult to transport on account of their fugitive vitality, for too much, or too little, light, moisture or heat will readily cause destruction, and an hour in a low temperature has been known to destroy a whole consignment. Correspondents have, more than once, been known to complain of consignments sent by planters from Trinidad as having arrived at destination "utterly useless owing to the long transit." Having successfully sent plants and seeds over the same line of route, the writer is of opinion that the failure was not due to the length of the journey, but to defaults in picking and packing; and to the season chosen for transport.

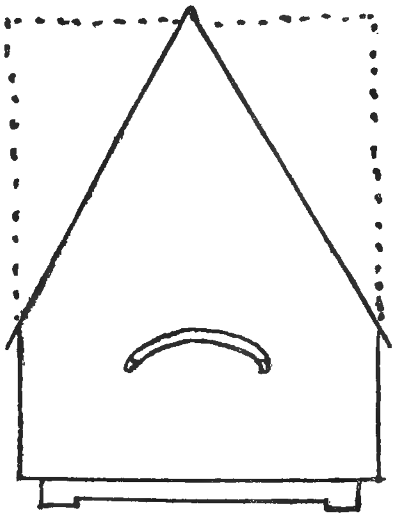

FIG. 62.—A Wardian Case.

Home friends unacquainted with tropical plants are apt

to conclude that cacao seeds may be gathered, dried, and despatched as easily as the ordinary seeds of the garden, and are much surprised when informed that cacao seeds cannot be dried without at once losing vitality, and that this is a common feature with many tropical seeds. Cacao seeds may, however, either be transported in the pod, or in packing which does not absorb moisture from, or supply it to, the seed; they may as an alternative be placed in a position to germinate slowly, or be sown in suitable earth to germinate and grow during the voyage. A certain amount of success will generally attend any of these methods, but only experts can decide which is the best to use under certain conditions. In 1893 the writer successfully transported 25,000 cacao plants from Trinidad to Nicaragua, a report on which is to be found in the Trinidad Official Bulletin of that year. Many thousands of seeds have been sent to Africa, both to German and British possessions, and it is within our knowledge that further considerable supplies of seeds have been supplied by various persons to European plant dealers for re-export to African States. Success, however, did not always attend the earlier efforts, and it has been our care to study the reasons which caused failure. This it was which enabled us to adopt such measures in the end as led to successful transport.

Tropical plants and seeds will not stand low temperatures, and in our opinion most failures are due, first, to their being sent at seasons when they have to encounter en route temperatures unsuitable to their welfare; secondly, to the want of suitable preparation; and thirdly to their being sent in packages not adapted to secure safe transport. They must not be sent in too large a package or fermentation will destroy their vitality, especially when they are passing through hot climates.

"Wardian cases" stand first in securing safety in transport of plants and seeds, and in these packages cacao can be sent long distances. These cases are made in various forms, but the most suitable is that adopted by

the Royal Gardens, Kew, and other botanical and commercial establishments, as shown by Fig. 62. Figs. 63 and 64 are also used, but they are not so suitable for many good and sufficient reasons. These cases are built with glass roofs, covered with strong slats or laths, to protect from breakage. The glass should be roughened sheet, or,

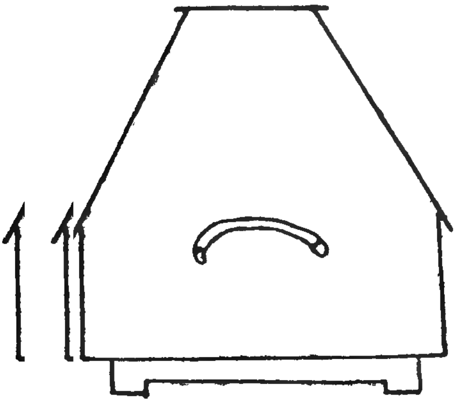

Fig. 63.

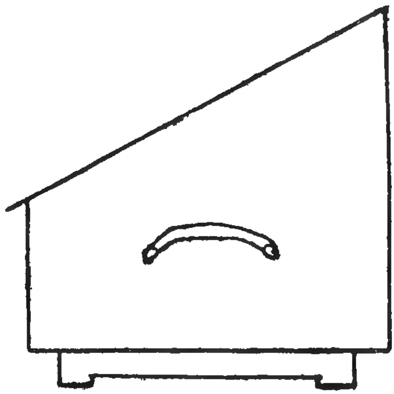

Fig. 64.

if that is not obtainable, other strong glass, not easily broken, covered on the inside with a thin coat of white paint, which should be thoroughly dried before use. Wardian cases are primarily intended for protection, maintaining a suitable temperature, securing a sufficiency of moisture, and affording to the plants a sufficiency of light during transport. In Fig. 62 the pointed gable roof allows the moisture condensed upon it to return to the soil in the case on both sides, and thus prevents the roots suffering from drought, and the steep slope of the roof prevents the drip of condensed moisture, which is specially harmful to plants in packages. In Fig. 63, with its partly flattened roof, there is generally considerable drip; and in Fig. 64 the condensed moisture will partly drip, but will mostly be delivered at the lower side of the case, leaving the soil too dry under the higher point.

Cases should not be built too large, and should be prepared for such transit as they may meet; and care should be taken prior to despatch to ascertain what they are likely to meet. It is not intended that a case should be turned upside down, but this may happen on a journey, and therefore all well-packed cases should be cleated in the inside sufficiently well to allow of their being turned up without damage.

The ship's charges are less for cases Figs. 63 and 64, as the measurement is taken as square from the highest point, as per dotted line, and from this it will be seen that, although the best case for transport, Fig. 62 is also the most expensive for freight.

Sufficient ventilation should be provided for each case, but, at the same time, too much will damage the contents. For a case of the most useful size, the dimensions are: Length, 38 in., width 26 in., with gable as per Fig. 62, and for this, the ventilation should consist of an aperture of $1\frac{1}{4}$ in. diameter high up in each gable. This should be covered on the outside with a piece of perforated zinc or netting to exclude mice and rats, and on the inside it should be covered with a hollowed wooden shield, closed at the top, but allowing passage for the air to the aperture from the base; this should be at least 4 in. in length, and should be screwed on the inside. This prevents direct currents of air either entering or leaving the case, but provides a slow, suitable, and continuous current, which will avoid damage to the contents if the cases happen to get placed directly in the sun. If left without ventilation in such circumstances the plants would suffer badly from scalding. It may, however, be stated that Wardian cases are always better placed " 'tween decks " than on the open deck. The most suitable place is near an open hatchway, which allows light to enter daily, as a rule. A label notice on the cases to this effect will generally secure such a position from the ship's officers. Instructions should also be placed on each package asking that, in case of breakage of glass, the breakage may be mended by covering with a

baggage label or piece of thin cloth pasted on any fracture which may occur. It is essential that the case should be kept intact, and a couple of baggage labels will often save one which otherwise would be a failure.

Cases of the size already mentioned will carry approximately 1200 to 1500 seeds to grow on the voyage; but if year-old plants are packed, only some 100 to 150 can be carried.

The details of packing can hardly be given in writing, or if so given, would be difficult for any one unacquainted with such work to understand. Packing plants is a speciality, with which many, even good botanists, have not made themselves practically acquainted, but those who wish to witness the work done in proper form should obtain the privilege of seeing the work carried out at such places as the Royal Gardens, Kew, or some of the high-class tropical nurseries of London and Paris, &c., &c.

Probably the most important point in the transport of plants, is the absolute necessity for a proper consideration of the temperatures through which the plants have to pass en route. Tropical plants and seeds suffer very badly if subjected to low temperatures and they should, if possible, never be sent to pass through them, as if they do they pass at great risk. Of course, at freezing temperature every one naturally expects damage; but 32° F. is not referred to when speaking of a low temperature here, but temperatures of 50° to 55° F. It should be remembered that tropical plants, such as cacao, are grown in a temperature the mean annual of which in Trinidad is some 78° F., mean annual maximum 86° F., and mean annual minimum 69° F.* The extreme minimum sometimes runs as low as 60° F. and extreme maximum as high as 93° F. at various times of the year. Therefore when plants or seeds are said to pass a low temperature we reckon that 50 to 55° F. is the lowest they can bear with safety. Under exceptional circumstances they *may* pass with safety

* From meteorological returns, year 1907, Trinidad record. Decimals not taken.

temperatures little above freezing-point, but this is the exception, and not the rule, and those forwarding should always assure themselves that their consignments will not have to pass points where damaging temperatures are likely to be experienced. The most successful despatches of plants coming under notice have always been those sent through temperatures continuously high enough to enable them to pass with safety. Cases despatched from the West Indies in July or August for London in the majority of instances arrive in safety, while a case despatched in February or October would be almost sure to meet a cold snap in the Channel, or a cold hour on a wharf or railway platform; and its contents would be severely damaged or perhaps destroyed.

Cacao pods (each containing thirty to thirty-five seeds) can also be forwarded long distances safely if sufficient care is used in picking, curing, and packing. It is, however, not advisable to send them on journeys longer than fourteen to sixteen days; they have arrived safely in journeys taking as much as twenty to twenty-five days, but the risk of loss is great. It is of essential importance in forwarding pods that they should not be damaged in the picking. Every one of them should be hand-picked and not cut or bruised in any way, or they will not go safely even with the best package, as they rot as quickly as an apple when injured. The pods should be cured or wilted for a day or two in dry air before packing, and the packing should be carried out so as to afford ventilation and prevent heating or fermentation. This can best be done by packing them in shallow, well-ventilated cases, in what is known as "wood wool," or fine wood shavings, not sufficient, in any case, to gather heat and induce fermentation. Small quantities of seeds can also be transmitted by parcel post, in one- and two-pound biscuit-tins, the seeds being packed in sterilised coco-nut refuse, but even these should not be sent except during warmest weather. The best cases for sending pods are shallow ones, 30 in. long, 1 ft. deep, and 18 in. or 2 ft. wide. The ventilation apertures should be

protected to prevent entrance of mice and rats, as the pods are tempting morsels for these rodents.

It will be gathered from the foregoing that the transport of cacao plants and seeds is not a specially difficult matter if the principles which conduce to safe transport are fully known and observed. The ordinary planter is, as a rule, too much engaged in other duties and has too little transportation to attend to, to warrant the expenditure of time in undertaking practical work of this kind, and it cannot be expected that he will possess the experience which will ensure the regular success obtained by those who have been carrying on such work for a number of years. As a matter of fact, the transport of plants is a business or speciality, and the owner, company, or syndicate requiring seeds sent to long distances, cannot do better than obtain expert assistance and advice, this being cheaper in the end, rather than place their reliance upon the best intentions of friends who are willing to assist them, but whose experience is not such as to conduce to a successful issue.

CHAPTER XXIII

MISCELLANEOUS NOTES

Spraying.—There can be no doubt of the effectiveness of the spraying treatment in ridding certain members of the vegetable kingdom from insect and fungus pests. It is a pitiable case, however, when such applications are recommended, where there exists no possible means of applying sprays in a practical manner; which may be defined as one in which the method is effective, and can be carried out at a reasonable cost. It has been reported that spraying was once recommended for an attack of aphis, or "green fly," on a field of sugar-cane, by a gentleman who had seen it effectively applied for ridding roses of the same class of pest in an English garden. It would have cleaned the canes, no doubt, but its application was impracticable, or, if partly practicable, too costly to be entertained, and too lengthy an operation to be carried out in time to prevent the greater mischief. The conditions existing on cacao estates are of such a character generally as to prohibit the use of sprays, unless the rows of trees are made more accessible by cutting roads and making bridges for the admission of suitable machines for dressing a large area daily. This is a difficulty which must be overcome before spraying can be confidently recommended generally to cacao planters; not because it is ineffective, but because existing conditions prohibit its use on the score of expense. It is, of course, an easy matter on flat lands to apply sprays to orchards, in, say, the fruit gardens of California, or in an English hop field, but it is quite a different matter to apply the same methods on a tropical estate, where there are—in the main—no suitable means

of access to the trees, especially on hillside lands. Sprays, in temperate climates, are largely applied for destroying pests when the trees are in a deciduous state, *i.e.* when bare of leaves; but the application of sprays to trees, which are practically evergreens, is another and much more difficult matter; and any method adopted, to be effective, must first be practicable. Many estates in the West Indies exist under conditions which prohibit anything but the knapsack sprayer from being used, and the application of sprays to an estate of 100,000 trees, situated on a hillside, is a task of no ordinary magnitude. When we read of the application of special sprays to certain pests as having attained a successful issue, it is not always safe to assume that because this is so in the one case, it must be equally possible in another; for it may have been carried out in the first case under totally different conditions to those existing where it is desired to adopt it in the second.

There can be no doubt that the application of sprays requires the presence of a high order of intelligence among workmen, in order to carry out a successful campaign; and while this may be present in a Californian orchard, or a French vineyard, where such work has been carried on for years, yet it can hardly be hoped to have the same results from the class of labour attached to most cacao estates. Still, a beginning must be made, and skilled labour must be trained if such work is to be carried out economically and successfully. Pioneer work of this class is always wearisome and disheartening, but it is to be hoped that conducted under the lead of careful advisers the efforts of to-day will result in substantive improvement in the treatment of the pests of the cacao field.

We hear of sprays recommended for killing off mosses, lichens, &c. Now mosses and lichens are vegetable growths as well as the cacao-tree, and it is not unreasonable to suppose that a poison (*Cupric sulphate*) that will kill the one must inevitably injure the other in some measure. In fact it has been discussed as working serious injury and permanent damage to the plant itself. The *Journal of*

the Board of Agriculture of England published some little time since an account of investigations into the "Effect of Copper Solution on Plants," on which a note appeared in the *Bulletin* of the Trinidad Botanical Department as follows:

"This chemical is largely used as a fungicide, and some of its solutions must necessarily be absorbed by the soil when spraying operations are performed. That this operation should be done with great care appears strictly necessary owing to the effect of this chemical upon the roots." Herr Richard Schander says: "The effect on plants of the copper left in the soil by spraying can never be beneficial, and in any case the effect must become apparent much later than the application of the solution, as it would be absorbed by the soil."

The author considers it proved that copper is injurious, and that plants can only absorb a very small quantity without injury. It follows, therefore, that plants growing on ground on which copper sulphate has been cast will be naturally weaker, and thus suffer more from a following attack, insects or fungi, than land free from copper.

It may be pointed out that some persons quite disregard the poisonous character of cupric sulphate, and have even recommended that it should be applied to the roots of the cane, in order to render them fungus proof; but of late little has been heard of this proposal.

It has also been argued that because "Bordeaux mixture" is largely used in vineyards, it does no harm to the vine or to other plants to which it is applied. This assumption is often made, it is feared, because the resulting damage is not at once apparent after application; or, when it does appear, is attributed to other causes than the action of copper sulphate. Some of the sprays used for destruction of insect pests are, however, quite harmless in their character, and can be used with great freedom and without danger.

The methods of spraying have become somewhat of a craze of recent years, and some cultivators go to unreason-

able lengths in the application of the various formulæ. In fact, it has become the fashion to spray, and it would appear that nothing but spraying can satisfy the public.

Looking at the matter carefully, the planter and cultivator will find that "all that glitters is not gold," and that spraying is not an unmixed blessing, and is not, as many suppose, the "cure all" and "heal all" for the many afflictions to which plant life is subject. It is not new in practice, or principle, as it has been in use in various forms for the past century, the writer having used it over forty years ago for plants in general, but it has now become largely popular through the advertising by manufacturers of spraying machines; in fact, it is one of the "patent medicines" of the plant cultivator; and like such medicines, while having at times a sound basis, may be much overdone under the influence of fashion of the day.

There are sprays which will kill the plant as well as the pest, and there are others of a harmless character, and numerous pitfalls await the inexperienced in the art, some of which are referred to in order to inform cacao planters of what they may expect in carrying out the "concise instructions" of the sellers of spraying machinery. "Concise instructions" generally mean a hash of directions, non-committal in their tenor, irresponsible in their effect and unsatisfactory in their results, it being impossible for the experienced to inform the ignorant, in a few words, of the necessary procedure acquired by years of practice. An Administrator in one of the West Indian colonies some years ago issued an order to his Botanical Department to produce leaflets giving "concise" instructions for the cultivation of various economic products, and was answered that, when it was possible for a general to give concise instructions for fighting a battle, a doctor for setting a leg, or a chemist for ascertaining the amount of available and assimilable plant food in soil, then, and only then, would it be possible to issue "concise" general instructions for the use of planters in cultivating the various productions

of the field. It is not possible, and only a charlatan would attempt to provide it.

While there is a great deal of good in spraying, and while it may be of the greatest value to the planter, it must be used with discretion and judgment by those who can apply their own experience, and that of others, to the special matter under treatment, in order to avoid failure and confusion. Spraying is, in fact, a business in itself, and in many countries where it is used experts exist who are engaged to carry out the work under methods which are guaranteed, and who are paid according to results. Amateur applications, unless the result of study and experiment, are often unsuccessful. The operator must know, first, what to spray; second, what to spray with; third, how to spray; fourth, when and how often to spray; and fifth, he should be able to decide by microscopic observation whether he has secured good results or the reverse, *i.e.*, whether he has killed the organism—plant or insect—against which he instituted his campaign. Many may say, "Oh! I know what to spray," without knowing all the assertion means. It is frequently recommended to spray for "canker." Well, what is "canker"? Now, canker in the field sense may be any one of several different things. According to mycologists, it may mean *Phytopthora,* or it may mean *Nectria,* or even *Diplodia,* each of which requires different treatment, and unless the operator knows one from the other and the treatment or application required for each he does not know "what to spray." He may say, if the formula is before him, "I know how to spray." Does he? Well, if he does, he will have to know how much spray is enough to use, its strength, and how to put it on. If he starts to spray a pod attacked by Brown Rot (*Diplodia*), and finds on examination with instruments that all the spores on the pod are destroyed, and concludes the examination satisfactory and the spraying effective, he is much in error; for if he examines the pod a few hours afterwards he will find that the spores have reappeared as plentifully upon the surface as he first found them, and that another

application is necessary, and he will have to continue the operation for many days or weeks in succession. In such a case it cannot be said that the operator knows "how to spray." He does not; and from the beginning he has, for want of experience, been doing work which is of a useless kind, although not utterly so, because he has actually killed a certain (small) number of fungus spores; but how much better would the work have been performed had he collected the pod and had it destroyed by one of the several methods recently suggested? If the operator is asked to spray "canker" he will proceed probably by the stereotyped process which has been commonly laid down, viz., to cut out all the cankered area, spraying it before, after and during cutting, and then treat the wounds with the barbarous "Salamander," or heated iron of Ceylon, and with antiseptic dressings.

Now no one, not even the most expert mycologist, can tell in the field when all the cankered area has been cut away, especially if treating *Nectria Theobromæ* or stem canker, or canker induced by the Black Rot fungus, and therefore the spraying given has done little more than reduce the number of spores, thus preventing in a small measure only the spread of disease, neither has the "Salamander," or antiseptic, had any better effect. It can, however, be ascertained in the laboratory whether the cuts have been made beyond the disease area, and also whether all infected material is removed, if sections of the parts are microscopically examined, but by no other method. Here again the planter meets a difficulty; he cannot get every canker spot examined under the microscope, for that would be impracticable with the many thousands to be attended to. This points out the fact that spraying cankers is only partially effective, and only serves for the destruction of the exuded spores, for the spray cannot be made to enter and distribute itself through the cells of the wood and destroy the growing mycelium existing there.

There is another factor to be taken into account in connection with the application of sprays used for different

pests. It is known that few plant troubles occur (whether caused by insects or fungi) without a controlling agency of some kind or another. In dealing with insect pests it is often found that they are attacked by both animal and vegetable parasites, and in some cases are directly consumed by members of the animal kingdom. Where attacked by parasites in sufficient numbers, the balance of Nature is preserved, and the pest is under control naturally. In cases where these are insufficient in number a study of their habits may lead to measures for increasing their numbers artificially, and thus attain the same end. In such cases the control will evidently be cheaper than spraying methods, but unless expert knowledge is available the planter cannot know what, when, and how to spray to advantage. Spraying under circumstances where there is a natural control means the killing of friends as well as foes and substituting a costly process in the place of the cheap natural one, which will, in the end, tend to increase the actual spread of the pest attacked. It is the same in dealing with the vegetable or fungus parasites which attack scale insects. In Trinidad there are fungi which attack and destroy or keep in complete check one of the insects attacking the orange. The humid climate of Trinidad allows of the growth of this fungus, which is quite harmless to the tree itself, but in drier climates probably would not maintain its predominance. Therefore, a scale doing no harm in Trinidad, owing to its being controlled by a fungus, might do serious harm in places where a drier climate prevails. Where such control exists, it is evident that spraying is not required, but until the natural order of things is fully recognised, it is probable that the uninstructed will be induced to follow the fashion and spray his trees; a course which for him would be an expensive, needless, and useless one in a great number of cases.

Spraying is often recommended as a preventive. It may readily be admitted that it is a preventive in some cases to the entrance of fungi to the cacao pods. If a spore rests upon the outside of a healthy pod it cannot

gain access to its interior until it obtains a means to do so, and so long as the skin of the pod is intact it will not suffer, but as soon as it is injured, even by the bite of a small "pod-hopper" or "thrip," mucilage exudes, the spores can adhere, and infection is made. It would be curious, indeed, if the time of spraying could be arranged to meet the time of the occurrence of all such infections, but as that is evidently impossible, and as the spraying itself has no permanent effect, being readily washed away by tropical rains, it is difficult to see in the method of spraying any effective system for the prevention of fungus infection. Again, as to the various remedies suggested for different pests. These render the work especially difficult for the ordinary manager and overseer, as what is suitable in one place is unsuitable in another, and what would render service in the one case would cause destruction in the other. It has been strongly argued that prevention is better than cure, and that the spraying of cacao pods and the covering them with a thin solution of cupric sulphate will prevent the attack of fungus disease. This presupposes that there are great quantities of infective material near by from which the infection proceeds, and that no rain falls to wash off the copper. We know that a single infected pod allowed to remain on trees is sufficient to carry infection over a large area; and surely it would be cheaper and more effective to destroy that source of infection than to spray a whole field to prevent infection. In any case to destroy diseased pods is the first measure to adopt, and spraying would naturally follow in order to destroy any spores which may have been already distributed.

We know the general methods adopted and the course taken where records are made on sprayed fields. So many fields were sprayed, and so many control plots were marked off, &c. On the control plots many more diseased pods were recorded than on the sprayed sections, and many more pods were ripened on the sprayed sections than on the control plots. From this it is deduced that

the spraying has been effective, &c., and therefore highly valuable. In some cases where it can be, and is, properly applied, there can be no possible question that spraying is effective in destroying fungus spores, as I mentioned at the beginning of this note; but what is intended to be conveyed is that only when it is used under the most careful control can good results be regularly obtained, and that badly applied it utterly fails in its object.

It also fails unless it is continuous; and it is highly probable that if due allowance is made for probable error —as is always done in careful experiments—on the ground of intervening factors or unknown influences, the affirmative of success so much wished for, and so often prematurely recorded, may not only be considerably reduced, but in many cases wholly obliterated. At any rate, it is clear that no proof of success will be complete until experiments have been under continuous record for a certain number of seasons in succession upon the same land.

The damage done by continuous spraying to the general health of the trees does not appear as yet to have had due consideration, nor has it been yet taken as worthy of record. We have abundant proof that cupric sulphate is destructive to vegetable matter in general; to which the reply is, that it is used in such small quantities as to be an unimportant factor when its influence on the trees is being considered. That it is a factor to be neglected has not as yet been shown, and, as I have previously mentioned, evidence is at hand to the contrary. Records of this kind should be made for comparison with the record of spraying successes.

A tree may be safely sprayed in one stage of its growth with a mixture which in a younger stage would seriously injure it, and it is quite certain that trees carrying open flowers should never be subjected to such dressings, unless some very imperative reason appears for so doing. If spray can kill lichens and mosses, it can also kill the much more tender flower of the cacao, and does so; and it cannot be expected to differentiate between tender growths of

vegetable matter, and even on the more hardy portions of the tree it has a certain effect, and if sufficient quantities reach the parts by single or continued application the injury will appear in due course.

√Mr. Barrett when in Trinidad recommended 5.5.50 as the formula for making Bordeaux mixture, without details. A young overseer mixed 5 lb. copper, 5 lb. lime, and 50 lb. of water. The mixture was indeed effective, for it was ten times too strong. It should have been *gallons* of water instead of pounds. The result of the application need not be discussed further than to say that the young overseer obtained experience of a kind which he has no wish to repeat. √

Another operator heard of Paris green as an insect destroyer on cotton, &c., and attempted to use it for the destruction of the ubiquitous mole cricket which destroys grass lawns badly in Trinidad. The result of the application was that large patches of grass were destroyed, while the cricket apparently enjoyed burrowing therein.

A rather humorous instance once occurred in which an operator was greatly discomfited when using Bordeaux mixture, a case the like of which may at times happen to even the " old hand." Having some tomatoes affected with leaf fungus, the operator prepared a suitable quantity in a large barrel, and, when ready, used it at sunset upon the afflicted plants. Next morning the tomatoes had the exact appearance of being stricken with a sharp frost, and when the sun gained strength showed that they had been completely killed. The Bordeaux mixture had been made in an unwashed whisky barrel.

Taken on the whole, therefore, it is considered that these remedies *can only be used to advantage under the hands of expert practical men trained in their use and application.* That they are useful under such guidance is not to be doubted, but in the hands of amateurs they are generally discouraging and dangerous, and should only be applied by trained workmen.

The best practice for the individual planter is to proceed

only under expert advice, and even then to proceed slowly, carefully watching results, and thus securing the necessary personal experience. To do otherwise is to run the risk of damage to crop and absolute failure, where, under proper management, success might have attended the effort.

Studies in Cacao Disease. Diplodia.—In writing of this there is no intention to scare or lead planters to become unduly anxious for their plantations, but merely to present actual facts which should be known to every one interested in the cacao industry. There can be no doubt that the destructive microscopic parasites causing disease in cacao are plentiful and persistent, and that the amount of damage they are capable of causing is not as yet recognised or realised. Among these diseases, one of the most prominent is that described in Stockdale's pamphlet as causing "Brown Rot" of the pod, and "Die Back" of the branches. This fungus is a "facultative parasite," or one which, though at first a "saprophyte," or grower upon dead matter, can and does afterwards become a very destructive parasite. It is described by Howard, Stockdale and others as bearing two kinds of spores, by the growth of which it spreads rapidly; how rapidly will be seen later. The first is one-celled and "hyaline" or colourless, while the second is brown in colour and once septate or divided into two cells, the latter being the mature stage of the former. These spores can both germinate on any wound or abrasion of the cacao-tree. Stockdale records that "Howard's experiments pointed to this fungus being a wound parasite and capable of affecting sickly trees." This fungus is scientifically known as *Diplodia cacaoicola P. Henn.* Recent experiments with the two forms of spores show that the hyaline spore does not germinate so quickly as the mature form, and grows from one point only until it approaches maturity, when it may grow from two points. The mature spore, however, produces growth from each of its cells, at or about the same time. The rate of growth made in our cultures of the two forms is as follows: For the hyaline or immature spores 1.55 hours,

while the mature spores have germinated in a single hour. This result differs, however, from Howard's result, which is possibly to be accounted for by difference in the medium (culture fluid) used in the experiments. I am not aware what was used by Howard, but that used by the writer is made from material of a half-ripe pod. This is first pounded to a pulp, which becomes mucilaginous when mixed with water. The material is then strained through fine cloth and the resultant liquor is boiled and allowed to cool. By this time it has lost its mucilaginous character and has assumed the colour of brown sherry. It is then filtered and afterwards sterilised in flasks, and when cool is ready for use, and drop and tube cultures can readily be made by infecting it with a few spores of either form. It has been found that pods can readily be inoculated by inserting a minute quantity of the spores into a small cut, that the disease rapidly destroys the pod in a few days, and that a heap of empty pods rapidly rots when infected, and will produce myriads of spores. Specimens have recently come to hand which show that this disease is present in some pods which to the ordinary observer appear perfectly healthy. It has been found in the branches of trees of fairly vigorous growth, and it has been found in the branches, stems, and roots of young trees three to four years old, which are said to have died from " root disease." In the pods the presence of the pest is generally discovered by the appearance of brown spots which precede the rot, but this is not always the case, as pods apparently sound will develop in a damp chamber the characteristic fructifications of the fungus. In " root disease " the first indication of mischief is shown by a yellowing and rapid drooping or wilting of the leaves, on the appearance of which the damage is complete and the tree rapidly becomes dead and dry. The fungus, however, can be found by placing pieces of the wood and bark in damp chambers, when the " pycnidia," hitherto unseen under the bark, develop and discharge the spores in spiral or contorted, gummy threads, which, though white when first exuded,

rapidly become dark brown or nearly black as they assume the mature two-celled form. In the roots of trees lately examined, there was strong evidence that young trees had become infected through cutlass wounds made in the stems just at the surface of the ground by workmen when "brushing" or "billing" down the tall weeds which flourish in young plantations. Certain mites were noted during our studies which carried some of the spores attached to the hairs of their bodies, showing the possibility of transferring spores from one point to another by insect movement.

It may be noted that in recent works reference is made to a fungus determined as *Lasiodiplodia sp.*, but that all writers have, to the present time, been careful to place it among the so-called *Fungi imperfecti*, which means that its history is imperfectly known. Our examination of the original specimens, however, showed nothing more than the organs of *Diplodia cacaoicola P. Henn*, and hence it would appear that this fungus is accountable for "Pod disease"—"Brown Rot," for "Stem disease"—"Die Back," and for the "Root disease" of young plantations. The same fungus, or possibly one nearly allied, has been detected here (Trinidad) on *Castilloa elastica*, causing a disease of the roots, on sweet orange stem affected with "Root Rot," and on the fruit of *Clusia rosea* in the open forest, which appears to be strong evidence that the fungus is indigenous to the colony and widely distributed, although only brought to notice during recent years. It will be further noticed that in the lectures recently delivered before the Agricultural Society no mention whatever is made of any disease caused by *Diplodia cacaoicola*, and that the greatest amount of disease is attributed (even canker) to the action of *Lasiodiplodia sp.*, for the determination of which American botanists appear to be responsible, but which may probably prove to be a form of, if not actually identical with, the long-known *Diplodia cacaoicola*. It will be remembered that the identical sample on which the determination was made was collected by the writer, who

found nothing more in it than could in his opinion be most properly ascribed to *Diplodia*. It is possible, of course, that points found by others have been overlooked by him, but if so, it is full time that such points were fully worked out, so as to confirm the determination, or to rid us of the bogey of a disease which was brought to notice.

With regard to measures to be taken to control or prevent the spread of the diseases caused by *Diplodia*, I am in full accord with Stockdale, who writes: "This disease does not readily attack trees in a vigorous condition of health. Every effort should therefore be given to thorough cultivation, all diseased branches should be cut out and burned, and all wounds should be followed by an application of coal tar or some similar (antiseptic, J. H. H.) substance." In 1907 the rapid growth made by the spores, which it has been seen are capable of infecting a tree in a single hour, shows clearly how important is such advice as that given above, not alone by Stockdale, but by all writers, among whom there is an agreement of opinion which necessarily adds to its importance. When it is seen and realised by the planters how dangerous must be the practice of leaving naked cuts or open wounds without a covering of antiseptic dressing, how dangerous to leave quantities of dead branches or prunings in the field capable of propagating the fungus by millions of spores, each capable of reproducing the disease in an hour, and how still more dangerous it is to leave heaps of empty pods infected with fungus to act as nurseries for the spread of the destructive organisms of such a fungus, they will readily forgive the earnestness which has induced students of such facts to lay them before the public. When the enemy is well known—and the principles which retard, delay, or negative his power for mischief—a much better fight can be maintained than would be possible were we in ignorance of the cause.

So far as we are yet aware, no application can be applied which would constitute a radical cure: but, nevertheless, planters may, by keeping a course of high cultivation and by adopting hygienic and preventive measures, do much

to prevent such diseases spreading and to secure a certain amount of immunity for their estates, and they certainly have it in their power to prevent such a disease attaining to epidemic proportions. Further studies of controlling influences should be made, many of which are probably at work though still unrecognised—such as the destruction of spores by insects,—the mite and the cockroach and certain fungi parasitic on the pest being at present the only ones recognised; but there are many other natural enemies to the growth of this fungus still awaiting discovery. There is no doubt that under certain conditions fermentation is very destructive to fungus spores. This points to the most suitable method of getting rid of the empty pods as disease producers by utilising them for manurial purposes, and regular plans should be made for treating them on these lines, rather than continuing the neglectful method of leaving naked heaps in the field which very commonly prevails. At present the disease does not seem to gather much headway, and this is probably due to natural checks upon its spread. The principal destruction by it appears to occur on poorly cultivated or inferior soils. Many contend that it is not present, but there are few estates on which it cannot be found. It is not recognisable to the naked eye until the result of its mischief is evident in the death of the pod, branch, and root, but nevertheless it can be found by the expert in unsuspected places where unfavourable seasons would cause it to show itself with destructive effect, and unless a proper watch is kept upon its action and progress, together with that of the equally insidious canker fungi, it is possible that it may become a very serious matter to that section of the planting community who are dilatory and unwilling to adopt hygienic measures, and are generally neglectful in the management of their estates. At the same time there is every reason to hope that, given clean, well-manured, well-drained, and well-cultivated estates, where hygienic methods obtain, planters have no need to be alarmed. One fact is certain, as seen in our last dry and unfavourable season.

Those estates where bad pruning, bad drainage, &c., prevail, and where " pick, pick, and keep on picking " is the first order of the day, will most assuredly be those which will afford no encouragement to the planter. It may be mentioned that *Diplodia*, though better known than *Lasiodiplodia*, is still placed by some authors also among *Fungi imperfecti*, and it is to be understood that there is much more to be learned about its history and habits than has yet appeared. Since beginning this work, we have seen *Diplodia* on the grape-vines and on grains of corn, and literature shows that in Europe species of it attack the holly, lilac, chestnut, mulberry, and various conifers. It is also reported to attack the avocado pear, the sugar cane, and the mango. It may be mentioned that the distinction made by various authors in regard to generic characters which distinguish *Diplodia*, *Botrio diplodia*, and *Lasiodiplodia* has not as yet removed them from the class known as *Fungi imperfecti*, or those which are imperfectly known. More recent observations appear to afford evidence that *Botriodiplodia*, *Lasiodiplodia*, and *Chæto-diplodia* are merely forms of *Diplodia cacaoicola P. Henn.*

Insect Attack on Plants.—Practically there are few " cures " for the destruction of insects which can be applied without damage to the host which is attacked, be it more or less visible or invisible, noticeable or unnoticeable.

In many cases the observer or cultivator is apt to conclude too prematurely that no damage is done by sprays or washes, a conclusion which " after-practice " may show to be quite erroneous, as discussed under " Spraying." That damage can be done, and has often been done, by such applications has been frequently proved, and therefore other and safer means would certainly be used were such means available and known to the cultivator.

The most natural of all methods for controlling the spread of insects is that found in the discovery of the natural enemies of the obnoxious insect, which are harmless to the plant attacked. We know that many of the common coccids, or scale insects, are destroyed by parasitic fungi

in situations where the climatic conditions are favourable. In such cases the insect seldom or never gets beyond control sufficiently to become a pest.

We know, again, that insects of this class are also controlled by insect parasites and by predatory insects, which feed upon and destroy them, a familiar instance of which is seen in the destruction of insects by the Lady Bird beetles, or *Coccinellids*.

The larvæ of some flies also feed upon *aphides*, plant lice or "blight," and there are numerous instances where insects of the sub-order *aculeatæ* (the wasp family) feed upon and destroy in large numbers insects which are injurious to plants or destructive to vegetation.

The application of remedies, washes, &c., is always open to disappointment of some kind. The wash may be improperly compounded. It may be too strong or too weak, in the former case causing destruction of vegetable tissue, and in the latter a waste of time, labour, and material in applying inert material.

There can be no doubt, therefore, that where possible Nature's methods are by far the best, and that the greatest progress in control work will be made in the search and discovery of means of natural control, which Nature, in most cases, places close to hand in waiting for discovery.

A recent writer says: * "Extraordinary multiplication is counterbalanced in Nature by the predatory or parasitic habits of species of the same class." He also writes: "Resort to artificial methods, such as the use of insecticides in combating cotton pests, has not been much advised for *practical* reasons, but if their use should become necessary, and it were shown that they *could be used effectively*, the question of practicability might disappear." (Italics ours. —Author.)

The question of control under certain carefully devised cultural conditions and the question of susceptibility of certain plants to attack are both well worthy of the closest study, as it would appear that certain conditions of health

* D. T. Fullaway, Hawaii Experiment Station (Bull. 18).

induced by some methods of cultivation render the plant under treatment susceptible to disease.

The old example of the cow selecting the sweetest grass or the grass she pleases, appears to hold good also of the living organisms of the insect world, which are seen to attack in some cases, and to pass over in others, plants in all respects similar. Why? we do not yet know; but when we find the answer it will probably render the cultivator capable of maintaining more efficient control over insect pests.

In the cacao field there are serious problems which require careful study with regard to both insect and fungus attack, in order to regulate the economy of cultivation and the production of good crops.

Control must be maintained if the best results are to follow, and the planter will be compelled to resort to artificial, until the means of natural control are discovered; but once the latter are known artificial methods must inevitably disappear, on the ground of both economy and safety. The methods of control now known may be stated as follows:

Artificial control	Palliative Preventive Exterminative	Expensive Dangerous
Natural control	Effective	Economical Safe

The force of natural control, or of pitting the forces of nature one against the other to maintain a suitable balance, is not yet fully recognised. Wonderful progress has been and is still being made by professors and others; but professors cannot do all the field work, and the planter should recognise that, in order to manage economically, he should at least possess a discriminatory knowledge of the sciences of mycology and entomology, so as to be able to note in his daily rounds (for use in after practice) the natural means as yet unknown, which he may, and possibly will, find at hand to assist him in the control and working of his estates.

CHAPTER XXIV

HOW JOSÉ FORMED HIS "COCOA" ESTATE

This is the title of a little brochure published in Trinidad some years ago by an anonymous author. The subject is dealt with in a strong vein of humour which appeals to the Spanish cultivator and to others. The author briefly describes his difficulties and how he overcame them, affording an insight into the methods and practice which existed in bygone years, and also into those of the present day. It is, in fact, the groundwork of the method of modern planters; and shows the lines on which the cacao labourer has been trained in the past. Although there are a few points which in the opinion of some might be improved, there is, on the whole, a lot of good in it, and as it stands, it is considered a useful record of work as conducted in past years. The old people evidently knew what they were about, and when we remember that some of the largest and finest cacao estates in Trinidad were formed under the methods described by "José," it is evident that an amount of success must be credited to them, which compares favourably with that attained by more modern methods. It may be mentioned that a new edition of this brochure has been published in a somewhat modernised form, but it is considered that the older edition has a value of its own. There are some few items in the little essay which would not read well, and some hints which would lose a great deal of their effect if they were written in plainer language. To the cacao planter it is amusing reading, conveying not a little good instruction, and is useful for comparison with more modern writings. This must be my excuse for reproducing at length. It will be desirable, however, for

the benefit of the uninitiated, to preface it with the following glossary:

Despidido	= a parting drink.
Morocotas	= Spanish gold pieces.
Caramba	= an elegant "Cuss" word.
Sancocho	= a favourite stew, flesh, fowl and vegetables.
Aguadiente	= strong water—rum, whisky, &c.
Boucan	= a level cemented floor for drying, also a fire heap.
Madre del cacao	= mother of cacao. Shade tree. Erythrina, &c.
Amigo	= my friend.
Compadre	= ditto.
Immortelle	= shade tree.
Bucare	= the lowland shade tree.
Anauca	= the hill shade tree.
Agouma	= a weed used in soup.
Malojo	= corn or maize trash.
Farine	= meal from cassava.
Casaripe	= cassareep or the inspissated juice of cassava.
Lianes	= ropes of climbing plants.
Rastrojo	= overgrown with bush.
Bachaco	= the parasol ant, very destructive.
Peones	= labourers.
Guatepara, or Guatepalo	= Trees which smother with a clasping growth. After the animal known as the "sloth," which, making a clasp, never lets go.

HOW JOSÉ FORMED HIS "COCOA" ESTATE

Introduction.—I had been listening for a long time to the opinions of several and divers planters. My Grenada friend said: "Away with the immortelle trees. Plant the avocado and nutmeg. You will have three crops." Mi Amigo Corsicano said: "Diavolo, let the cocoa-trees grow, let them branch off like any other fruit-tree, say the tamarind. The 'choupon' or sucker will in time bear much more than its mother." I was not satisfied. I bethought me of old José, the owner of that luxuriant estate at Oropouche called "Mi Amor." I determined to find out how he formed it.

José was not in a good mood for an interview. A Ward Officer was in his yard asking for the year's taxes. Not that José could not pay the taxes, but ever since he had "leased the land," as he termed it, he had determined to let the Warden send for the rates every year.

After some time old José came to himself. I immediately tackled him about himself—his weak point. I had heard of this.

"*Caramba*," said he; "yes, I have come from the land of Bolivar, where we are not zealots, where the *chopo* makes bad men understand reason, and where every man is a man, no matter whether he is white, green, black, or blue: I am here through a family affair, having arrived in the island immediately after the great war of the Federation, in the fifties—I, José, who served under the valiant Falcon."

I had heard that he arrived here with a few *morocotas* tied around his waist, the *janiero* system of carrying money over there, but he didn't mention this. (This system I have found is practised here just now a great deal, not only by the coolies, but even by some creoles. It is very, very safe, for neither your friends, family, nor the Savings Bank people can know that you are possessed of any ready money.)

José, I had learnt, was a very hard-working man. Two things he liked, viz.

to work and to fight. I had enough to do to keep him away from his reminiscences of many fights in the land of Castro, and to confine him to my subject —" How he formed his estate." After his stock of *Carambas* had been almost exhausted, he deigned to give me the following:

2. *Petitioning and Surveying.*—" When I arrived here I immediately called upon my old countryman, Pedro Quitacalzon. He very wisely advised me to go in for some land and so form an estate and be somebody in Trinidad. He explained to me how I must first of all petition for the land, then have it surveyed, and after must pay taxes on it. The trouble this petitioning and surveying cost nearly drove me mad. Indeed, *Senor*, my headache, almost perpetual, dates from that time. The felling of the virgin forest was nothing compared to it.

" Having got my Crown grant, one fine Monday morning, after having been somewhat fortified by some good *sancocho*, and encouraged by a good glass of *aguadiente* I started with a new axe and a ' Gilpin ' cutlass, Quixote-like, to fight the mighty *muro*. Moral courage, indeed! Amongst thorns, wasps, snakes, &c. I had to perform my first month's labour in *talaing* or felling the underwood. I had *talaed* in that month half a quarrée of land or more. Then I waited for about three weeks, when I ' put my shoulder to the wheel ' and essayed my strength against the monarch of the forest and its courtiers. That done, I waited three weeks more before I started to burn.

3. *Burning.*—" Having got the land surveyed, &c., I thought my troubles were over. Far from it. I did not know of the Fire Licence Ordinance. My friend Quitacalzon advised me to take out a licence. I have to say now that it is one of the few laws made in Trinidad which benefits everybody, though it is to be regretted that a few people can still manage to evade this law. I didn't like that Ordinance then, nor does Beharidass now. I set fire to my lands at the finishing of the dry season of that year. Being alone, the fire nearly escaped me twice, but I easily stopped it. My method is to beat it down near the trace with banana leaves. I then had to make *boucans* the second part of the burning process, which consists in collecting and piling up the larger wood which was not burnt before, and firing them. After this I had my field, *Senor*, almost bare. There was nothing much left on it to interfere and give trouble when I should begin planting and draining. I waited for some days, giving time for the earth to cool down, and then began planting.

4. *Lining and Planting.*—" I first started on the difficult task of lining and putting in pickets at 12 feet from each other. This is a special art in itself. At the foot of each picket I planted two or three cassava roots at an equal distance from each other, say, half a foot. Then I put in close to the pickets two or three cocoa-seeds. These seeds I took from the middle of a half-ripe cocoa-pod of the best quality—the biggest seeds in the biggest pods I could find.* The cassava roots were planted for two obvious reasons. First, to serve as a shade for the growing cocoa-tree; and, secondly, to get a crop of cassava in a few months' time. Then I put in some figs, plantains, and tannias midway between the rows of pickets. In some bad spots, where the land was poor, I planted double the quantity of figs, and here and there I planted the bitter cassava and the maize, whilst I threw away a few seeds of the pumpkin, cucumber, and ochros about the field. All these served me as shades as well. Then I planted the *madre del cacao* at a distance of 25 feet from each other between the rows of pickets or *ventana* where I had put in the cocoa seeds. Nowadays, *Amigo*, I see that rice is one of the first things planted in a new field, and I also observed in several Agricultural Contracts that the planting of this food is prohibited. I have planted some in my time, too, and did not see how greatly it affected the land. When the land is good, *Compadre*, nothing will affect it, and once it is bad, well, get your guano at the lowest possible cost, and be prepared to mortgage your estate and say *Buen Naje.*

* A good method of selection by seed.—J. H. H.

"My pickets being put at 12 feet from each other, an acre of land gave me 302 trees. At 14 feet by 14 feet it would have given me 222 trees, or at 16 feet by 16 feet 170 trees, 10 feet by 10 feet an acre would give 435 trees, but I have found out that 12 feet by 12 feet just will give the quantity I think gives the best results and suit my purpose.

"Some planters now *Socio*, will plant *immortelle* at 40 feet. This, I think, depends upon the soil and the locality, as in places where the soil is indifferent the figs and the *immortelle* must be planted nearer and nearer.* I always planted the *bucare immortelle*, as I consider it better than the *Anauca*, as it is not so easily uprooted by the winds. There are in the modern school some planters who would like to do away with the *immortelle*, but, *Caramba ! amigo !* let them go on, but don't you, if you have any to spare, lend these people money.† The *immortelle* is necessary—vitally necessary—on a cocoa estate. Cacao-trees always look healthy and bear well under them. The *immortelle* is truly the *madre del cacao*. It does not only protect the cocoa from the great heat of *Padre Sol*, but also the soil from the heavy showers that would otherwise wash its nourishment away, and also, like the figs, enriches the land.

5. *Vegetables, &c.*—"The vegetables came to perfection in a short time, but before any I got a crop of *agouma*. This *agouma* as you know grows of itself from any land that is lately burnt. Ramsammy nowadays will sell this in the nearest village. Next I had my crop of *maize*. What I didn't require for *arepa* or *juangoo* and balls—a nice food, *companero*—I sold out, leaving always some to feed the fowls with. The *malojo* or corn bush was always welcome to *Paranda* the *burro*.

"The manioc or bitter cassava in twelve months' time had come to perfection. I had the cassava bread and *farine*, not counting the *carta* or *casaripe* —a sauce which beats your Yorkshire or Worcestershire, *Senor*. The old woman, too, did not require to buy any starch. Between eight and twelve months the creole favourite vegetable—the plantain—had come to perfection. The plantain will grow and bear in any part of the island, but the best results are obtained in a rich soil. The *tannia* is in its glory on the hills. The northern range of hills is especially adaptable to it. The tannia in six months' time is ready for the market. I never pull a tannia but dig around it, taking away the vegetable, and then cover it up again with the soil. In this way I ensure another crop from the same plant. In four to six months the sweet cassava or manioc is good for the table.

6. *Nurseries.*—"After I finished planting I made a nursery. This was in anticipation that many of the cocoa-trees would from some cause or other die, and I would have to replace them in my first cleaning. Beside the cocoa nursery, I also made an immortelle nursery. Cocoa nurseries I always plant at the latter part of the year. I prefer to have the nurseries in cut bamboos, as a safe means for transportation. The bamboos are easily removed, whereas, suppose the nursery is on the ground, the digging and transference of the trees will cost a lot, and then how many will survive the operation. My immortelle nursery I generally make in a very cool spot and plant the seeds at a distance of 8 to 12 inches apart. I always cover the spot with fig leaves. (Fig equals various members of the banana tribe.) My land being all planted up, whilst awaiting the provisions to come to perfection to help me in the market, I had to start on my next duty.

7. *Cleaning or Weeding.*—"A few weeks after planting, the field began to show here and there patches of green grass—the *agouma* and the *z'oreille mulattes*, and where the soil was a little sterile, the *camboot*. The two former can be made use of in the kitchen, but the *camboot* will be rejected even by a starving *burro*. Great care must be taken in the first cleaning of a field. Near the pickets where the cocoa roots are, the hand is better used. Select labourers must be employed for this ticklish job. I have found Sammy the best sort of

* Sound argument.—J. H. H.

† Good.—J. H. H.

labourer for this. I always gather the grass, the dry leaves, and spread evenly. These in time will rot and be converted into manure. In four months' time I had my second cleaning done.

8. *Young Cocoa-trees.*—" Young cocoa-trees require constant light trimming so that they may grow nicely and make fine trees. The *lianes* which envelop them must be removed, and the fig-trees around them must be cleared of all dead leaves so as to give ventilation. When the figs are clustered they do not bear well. Some planters, *amigo,* through lack of means or other reasons have recourse to ' reundiaing.' I do not recommend this process as the nourishment of the trees is thereby removed. It is certainly better than leaving the young trees in high bush. This ' reundiaing,' or round-ridging, is done at a distance of 3 feet around the tree. In cleaning young plantations some modern planters, I now observe, accumulate the grass, rubbish, &c., in the middle of a row. I always prefer to spread my rubbish evenly over the cleaned ground,* as this prevents bad grass from growing rapidly, whereas by the *accamillonar* system, certain parts after the cleaning, or rather scraping, process, remain exposed, an easy invitation to pop up the vexatious *camboot,* and the undesirable *gamelotte.*

9. *Pests, &c.*—" When young, the cocoa-trees are often attacked by the beetle. I can easily discover the glue-like spots on the trees where the beetle had been and deposited its eggs. I have found out that the best time to destroy these glue-like spots is early in the morning or late in the evening. At these times one is likely to come across the beetle itself. For myself, I prefer in the morning—I speak by experience—for in the evening with my *aguadiente espejuelo* on, I might see too many beetles.

" My small estate being on the high road to its bearing stage, I had a few weeks' rest; during that time I had a look right round the plantation. I observed that the *rastrojo* and some high woods surrounding it somewhat prevented ventilation. I made what is called a *border.* Borders around an estate is quite obligatory. The manicou, squirrel, rats, and snakes do not like this clear space around a plantation. These animals are pests, as every planter knows. I forgot to mention the *bachaco.* Ah, *Amigo!* long ago this pest gave us battle, but nowadays—who invented it, but it came as a blessing—a sort of fluid, *Senor,* which destroys them instantly. It goes under different names, viz., Vino de Bachaco, Calypso, Fuma, Bachacticide, &c. &c. You will find directions for using it on the bottle.

10. " *Chupons* " *or Suckers.*—" The pruning or removing of ' chupons,' &c., on a cocoa-tree requires some skill. This is done a few months after the field has been trimmed. By that time the ' chupons ' and the ' palmas ' have grown to a certain size. Some ' palmas ' would grow into good branches and sometimes they grow in clusters. A steady hand, therefore, is required, and skill to select for removing the undesirables—I have always ' chuponeered ' three months after my field had been trimmed, as by that time one can distinguish a ' chupon ' from a ' palma.' Doing this piece of work earlier I consider inadvisable. For instance, the ' palma volada ' which comes out on any part of the tree can easily be taken for a real branch when younger than three months. Some planters now leave the ' chupons ' and the ' palmas ' alone. I suppose their argument is that the cocoa-tree is like any other tree, and will in time give a good account of itself. I do not think so, and do not advise my friends to believe in this outrageous doctrine. The very name ' chupon ' or sucker suggests its character. A field planted 12 by 12 in the ordinary way would not leave enough space for the ' chupons ' to turn into good trees. I tell you, Socio, they can be left only where you have ' peladeros ' or bare spots, as the trees are a long way from each other.

11. *Drains.*—" I had now to consider the question of drains. In the hills drains are not required. They are essential in the vegas, as water from the uplands around will inundate the vegetation, thereby injuring it. The water

* Equals mulching, no new thing.—J. H. H.

remaining stagnant can only be let off through mains into some other part of the country. If this is not done, a sunny day will cause the sleeping water to get warm to a degree that will affect the cocoa-trees and sometimes destroy many. A 'madrina,' compadre, is the first to consider, as this will have to receive smaller drains as dug from time to time. The 'madrina,' or main drain, I always dig to a depth of 2 to 3 feet, and the smaller ones from 1 to 2 feet. I generally make main drains in the middle of the field, but if there are ravines so much the better.

12. *Trimming.*—" The trimming of a cocoa estate is the most difficult work thereon. After a crop has been reaped the trees generally throw off their leaves. This is the time some planters will begin the trimming job, but I generally tackle it between the months of March and May, as after this the trees rest, gain strength and put on their load for the season beginning in November. Skilled hands must be employed in the trimming process. The formation of a tree depends upon the knowledge and taste of a trimmer. There are various ways of trimming a cocoa-tree, and all depend on the shape, condition and health of the tree. When there are in a plantation trees in very bad order and entwining each other and no ventilation, then the skilful trimmer has a hard task. This job is called *derama ;* when an estate is in pretty good order and only requires clearing a little, my choice man would only *debarillar*, *i.e.*, cutting off some small unnecessary branches. When the ends of branches run into each other or bend down, it is necessary to *depuntar* just a little, that is, to cut off the tips of the branches. The most difficult trimming process is called the *entrasacar*. When the trees are laden with young fruit some small branches which are considered embarrassing must be cut off. Here a skilful labourer can show himself.

13. *Picking.*—" The picking, gathering, and breaking of cocoa are the easiest jobs on a plantation. The *esgaratadera,* or pruning knife, being got ready and sharpened, it is fixed, nailed, and tied to the end of a long and straight bamboo or other light and hard pole. *Guillermo* with the *peones* will start on an early morning, followed by the female gatherers to the field. A sharp picker can pick as much as six barrels in a day if the trees are loaded. Picking cocoa is preferably done by the 'job' by labourers, but, in order to do a good day's work, they will often fill the barrels with *mohongs* or green pods. A sharp over-looker will always reject these. A female labourer will always on an average break five barrels a day. The cocoa-pods are heaped together in different parts of an estate where the breaking takes place. Then it is headed to the curing-house, or else crooked on the *burros*' back or the mule's in *canestons* or baskets. When breaking cocoa, if in the wet season, great care must be taken not to allow it to get wet, as in drying it is sure to become black and mildewed. The cocoa will remain in the curing-house from four to twelve days. Then it is taken to the cocoa-house for the drying process.

14. *Drying.*—" The drying of cocoa may appear simple, but it requires some knowledge and skill to bring it to perfection. That cinnamon colour and that aroma which every one tries to get is certainly not a very easy task. You must begin at the beginning, *Compadre*, to get these desirable points. When the cocoa is heaped in the cocoa house it is then danced, rubbed with hands and opened in the sun. When the sun is very hot the cocoa must be closed. Constant raking is necessary. If these points are neglected, I think the desired object will never be obtained. This is the time—the first three days —when the cocoa must be watched and caressed, so to speak. No good ending could repair a bad beginning; you will change the colour of the scheme by artificial means, perhaps, but not the inside. In the wet season when 'Father Sol' chooses to lie low behind the clouds for days and your cocoa house is full, your curing house full, your trees loaded, then is the time to put on his mettle the energetic and practical planter. In such tight corners, *amigo,* I have known a friend to set fire under his cocoa house to keep the cocoa on the top somewhat warm. Another friend's plan (and he recommended it) was to

address his patron saint on such occasions. He never addressed that saint at other times.

"There are a few planters I know of, who have passed such troublous times, and have never sold black cocoa or thrown away any that got rotten in the drying process. The great secret is not to allow the cocoa to get wet, and to scrape the flooring of the cocoa house constantly to keep it dry and clean, and to heap the cocoa at night.* The heat through evaporation attendant on this heaping of the cocoa will help the drying of it. A certain quality of red dirt is used to give the beans that cinnamon colour or to preserve it. This dirt is applied when there is still a particle of glue attached to the beans. This process is largely used in my country, *Senor,* but only the manufacturers in Europe or America, I suppose, can say whether or not they like it or it is good. It appears now they like it. A cocoa dealer of our day to give a uniform colour to the miscellaneous brands he has purchased from Pedro, Dick, or Sammy will wash the beans in a heap, with a mixture of starch, sour oranges, gum arabic and red ochre. This mixture is always boiled. I can recommend the 'Chinos' in this dodge, who are all adepts in all sorts of 'adulteration' schemes. They even add some grease to this mixture so as to give the beans that brilliant gloss which you see sometimes. The *bois l'homme* bark is also used. Some brother planters, when they find their cocoa has a dirty hue, use the very *bava* of the cocoa as a wash to improve it. This *bava* can be got by cutting some green pods and soaking them in water for a few hours. The *bava* can be collected easily from the juice of the cocoa which is put to sweat.

15. *Overseering.*—"My idea of a good overseer, *Maestro,* is the active *Majordomo* who rises at 5 o'clock every morning, even before the labourers and his own driver, who in a few minutes will have looked round the cocoa house, inspected the stock and do many other minor duties to the satisfaction of himself and his employer. Then, he would give the driver his orders for the day and retire to take his coffee. Having partaken of this, which is a small breakfast in itself, as he will not return to his home before 12 or 1 P.M., my intelligent *majordomo* will don his leggings and his poniard and start for the field, where he can see how the work is going on. He must do the work as cheaply as possible and in a manner creditable to himself. When Juan Cachuping comes to lay a complaint against my overseer, or Ramdas Maraj on the sly will disrate his quality, I generally prefer to give leave of absence to complainants. When I hear Julian on the other hand praise him too much, I then make an inquiry. A good *Majordomo* is not liked by the showy, talkative, and meddlesome *peone.* Job-work pays an estate pretty well, *amigo,* as less supervision is required. Almost every work on a plantation can be done by 'job,' from the felling of the forest to the drying of the cocoa. I, however, will always sell the golden bean myself, and, to make sure, sell it locally than ship it to be sold in Europe.

16. *Parasites.*—"Cocoa-trees in some places, notably in cold spots, suffer from moss. Draining at once becomes necessary. Ventilation must be allowed too. The moss is removed by scraping it with a dandy brush or with a sharp-edged piece of hard wood or bamboo. This *deslima* process is necessary to any sort of tree. The *guatepajaro* and other parasitic vines must be removed, and also the *pines.* When the trees are covered with these they do not give good results, and will give less year by year until they die. I consider the removal of these vines one of the principal works on a plantation. *Si, senor,* let us take a walk to *Mi Amor,* you will not find a *guatepajaro* there. The average yield of cocoa per thousand trees is 10 bags. My estate gives me 15 bags. I know of several covered with *guatepajaro,* which only gives from 5 to 10 bags per thousand.

17. *Contractors.*—"*Amigo,* before you leave let me tell you about contractors. You must also take the *despidido.* Contractors for planting are good and they

* Preventing the growth of fungi.—J. H. H.

are bad. If you have spare land bounding with your estate you may give contracts for only three years. The contractors then would not have the chance of selling cocoa, because the contracts would not be at the bearing stage. Contractors who have bearing contracts generally do not know their boundaries and make the 'mistake' of mixing your estates' pods with their own.* If you have only virgin land you can give contracts for five years, but be particular to have the land lined and picketed for them at your desired space, otherwise they will plant the cocoa nursery-like, the reason being to get the greatest quantity of trees possible. You must see that they put the *immortelle* at their proper distances also. For myself, *Paysano,* I prefer to plant the land myself. You reap the provisions and the cocoa grows. It is only a question of time and patience. The ground provisions reaped are more than ample to pay for the cleaning. Besides you save the trouble of a doubtful co-partner. Look at poor Jean François who owns the neighbouring *San Façon* estate. He is always in the Courts with his contractors. He bought the land, felled it, made drains, killed the *bachaco* for the contractors, and still they are not satisfied. If one can do all these things, *Amigo,* what more remains to be done? Plant the land, of course! I would do that myself; with two cleanings the trouble would be over.

"No, *Senor, Mi Amor* was not formed by contractors. *Adios.*"

* But too true.—J. H. H.

CHAPTER XXV

THE HEALTH OF THE CACAO ESTATE

Many people have been impressed with the idea that it is impossible for Europeans or Americans to maintain their health upon a cacao estate.

That some estates are in unhealthy situations may be admitted; tbut hat cacao estates are unhealthy as a rule is very far from the truth.

Some estates have possibly been planted in districts which are badly drained, but these are in the minority; and the greater number of Trinidad estates have been placed in selected positions where, if care is exercised in observing hygienic principles in the arrangement of surroundings to dwellings, healthy and comfortable residential quarters can be made on a cacao estate as well as in any other place. Malarial fever is admitted to be present in the island, but it is generally looked upon as a mild affliction, in no way dangerous except when complications ensue.

This fever is spread by the mosquito, and planters have now learned the measures to be adopted to reduce the chances of infection. I have known a case where a gentleman of strong physique was constantly attacked with fever at intervals for several years, but who now resides in the same district without attack. This has been entirely due to necessary hygienic measures being adopted. If you have a residence where heavy trees are covered with numerous water-holding plants, with yards where there are stagnant pools, with guttering and drains defective or choked, it follows that the mosquito is present in numbers, and if a fever patient enters the area the immediate circle

of his neighbours is likely to be infected, but where due care is taken malaria is seldom found. The writer's personal experience of malaria is not an extensive one, although he has resided with his family for near upon twenty-five years in Trinidad. Happening to go into the country for a week some years ago, he put up on the estate of a friend. Some of the labourers on that estate were down with malaria, and seven days after his return home he was suffering from infection. The attack was not a bad one, but lasted for several months, reappearing at intervals of weeks; and although his family was somewhat numerous no other case occurred, principally owing to the care taken in adopting the necessary hygienic measures.

Provided that proper care is taken, with an intelligent supervision of any patient who may happen while travelling to become infected, any European can live as comfortably in a cacao estate residence as in one in any other part of the country. And many planters can be pointed to as spending their lives in such residences and enjoying excellent health.

On some of the slopes of our mountains, estates are found possessing residences which are treated by the wealthy as country residences where they go for a change of air. In such districts also we find residential owners in considerable numbers, who come to town for a change of air, not specially on account of health reasons, but for the purpose of breaking up the monotony of too long a residence in one place. Attention to general health is, of course, as necessary as in any other situation or climate, and excess of every kind should be carefully avoided. In the tropics fatigue comes quicker than under the conditions of a temperate zone, and when we see the "new chum" going walking at a great rate, it causes a quiet grin (if nothing else) at his evident wish to show us "how he's going to do it." A bishop once did this, but received a lesson which checked his efforts and made him a wiser man—and he took it "like a man." We can rest assured that he will find out in time, however, that violent exercise is far from economy, and that a steady pace pays better.

Intemperance in eating and drinking, in exercise, in sleeping, in work, or in bathing, are all apt to endanger the health. Indulgence in intemperance of any kind surely weakens the constitution and lays it open to attacks of disease; and very often the serious result of ordinary attacks is brought about entirely by the conduct and habits of patients. The health of a colony is blamed for the indiscretion of the colonist, and home people record another "poor fellow sacrificed to a pestilential climate," when it, in all truth, should read "another sacrifice of wilful indiscretion." Attention to general health is of the greatest importance—not that it is necessary to fuss over it, but merely to keep a strict watch on the daily habits and assist them when necessary until the immigrant is acclimatised. To become acclimatised takes as a rule from one to three years, and those who reach this stage most quickly are those who most quickly adopt the domestic customs—the food and practices of the country in which they are making their home. There are good scientific reasons for this when we learn that the necessary bacterial "flora of the stomach" differs in no little degree in the tropics from that existing under the temperate zone. It is well known that many of the bacteria assist the stomach in the digestion of food, and there are others which combat the effect of the pathological kinds and render them harmless. Until, therefore, a full bacterial flora is acquired to assist in digestion of tropical foods the colonist cannot be said to have become acclimatised. To acquire this readily it is best for the new-comer to dispense with the ever-present prejudice which such persons generally show to new classes of food and the different preparations it undergoes, and to make himself at home with the domestic arrangements which he meets as quickly as possible.

A man who will only consume beef-steak, ham, and potatoes, or other English or American food, will be longer in becoming acclimatised than he who adopts at once the practice of the country. It is also necessary that the mind should be settled. To him who comes to a country

and exhibits a dissatisfied spirit, complaining of everything and generally making himself and others uncomfortable, acclimatisation comes slowly, and sometimes serious matters happen before he becomes reconciled to his surroundings. To him who sets himself to make the best of everything from the start, acclimatisation comes readily, and he is more quickly prepared to meet the dangers to which in every country flesh is heir.

Excess of every kind should be avoided. It is a great temptation to the European living in a hot country to indulge in bathing to an intemperate amount, and if this becomes habitual it is sure to weaken the constitution and to prepare the subject for any attack of infection that may come along. Numerous instances are on record of the occurrence of serious results from intemperate bathing after unusual exertion. In such case it is much better to be satisfied with a fully cleansing sponge bath * than to resort to the plunge and shower so often indulged in with serious results. But what about the reaction, says our bather? Yes, what about the reaction? we reply. Do you not realise that to cause a reaction you must first have an action, and that this action is only obtained by the expenditure of energy, and that such an expenditure is often far from being conducive to health under tropical conditions? Those who live beside a flowing stream often indulge for lengthy periods in the plash of the sparkling pool; but we invariably find that the offender is one of the first to be affected by an attack of tropical disease, while if he confines himself temperately to a morning dip of short duration he generally runs free from attack.

Intemperance in drinking is more responsible for ill-health than any other cause. Hot weather, as we all know, causes intense thirst, and one is tempted with cool drinks of all kinds, from whisky and soda to ice water, the latter being relatively as bad as any. Ice water drunk in quantity is highly detrimental to health, but,

* In any case the skin must, of course, be kept well cleansed daily.

of course, is less harmful than alcoholic drinks. The famous " lime and soda squash " of the West Indies is also calculated to upset digestion if drunk too freely.

In no place is the effect of drinking while undergoing exertion better exhibited than on a field day with troops in the sun. It has been noted by the writer that the men who first " fall out " are those whose water-bottles are most freely used, while he who refrains goes through the work with a minimum of discomfort. If the mind is made up to refrain from drinking on the field to a greater extent than a mere wash of the mouth and throat, it is absolutely certain that a great deal more work can be done with less discomfort and less likelihood of feeling the after effects of fatigue. The more you drink with the view to getting cool the hotter you get, no matter whether water or alcohol is imbibed. After heavy fatigue a quarter-pint is far better than a quart, but many (the writer included) have found it impossible to refrain from indulging in large quantities, although possessing the knowledge that it leads to discomfort.

Indulgence of this kind, be it only ice water or " soft drink," has a prejudicial effect upon the digestive organs, and the first upset of the newcomer generally arises from this cause.

A cacao estate may be in an unhealthy district, but in the majority of instances when the hygienic conditions are properly arranged Europeans and others are able to live in comfort and at ease to their old age, examples of which can be referred to. The cacao estate is not *per se* unhealthy; some of them are when situated in doubtful districts, but the majority can with attention to hygiene be made as comfortable as any residence in a temperate climate, and some " old standards " are ready to proclaim them in regard to health prospects far ahead of anything in a temperate climate.

Much is made of fever in a tropical climate, but a careful examination of the death-rate shows that malignant fevers are much less prevalent than scarlet fever and small-pox

in large English towns, and the death-rate, too, is far lower.

On the score of health, therefore, the European or American resident on a cacao estate has nothing to fear, but, on the other hand, he has in many cases to congratulate himself on the healthiness of his surroundings.

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